DIV. OF HERPETOLOGY

1959, No. 2 July 24

Museum
QL
640
C18

UNIVERSITY
OF MICHIGAN
JUL 29 1959
MUSEUMS
LIBRARY

# Copeia

ESTABLISHED IN 1913

*PUBLISHED BY*

THE AMERICAN SOCIETY OF

ICHTHYOLOGISTS AND HERPETOLOGISTS

# CONTENTS

SKIN AND LUNG CAPILLARIES IN EUROPEAN COMMON NEWTS. By *Juliusz Czopek*..... 91

AMPHIBIANS AND REPTILES FROM THE PLEISTOCENE (ILLINOIAN) OF WILLISTON, FLORIDA. By *J. Alan Holman*..... 96

A MOTION PICTURE STUDY OF MATERNAL BEHAVIOR OF THE LIZARD, *Eumeces obsoletus* BAIRD AND GIRARD. By *Llewellyn T. Evans*..... 103

A STUDY OF THE SAND SKINK, *Neoseps reynoldsi* STEJNEGER. By *Sam Rountree Telford, Jr.*..... 110

DISTRIBUTION OF THE AMERICAN CYPRINID FISH *Notropis anogenus*. By *Reeve M. Bailey*..... 119

THE DRACONETTIDAE—A REVIEW OF THE FAMILY WITH THE DESCRIPTION OF A NEW SPECIES. By *John C. Briggs* and *Frederick H. Berry*..... 123

THE ROLE OF THE SENSES IN THE FEEDING OF THE NOCTURNAL REEF PREDATORS *Gymnothorax moringa* AND *G. vicinus*. By *John E. Bardach, Howard E. Winn*, and *David W. Menzel*..... 133

TWO NEW FLATFISHES OF THE GENUS *Ancylopsetta* FROM THE GUIANA COAST. By *James C. Tyler*... 139

A REMARKABLE NEW GENUS OF ANOSTOMIN CHARACID FISHES FROM THE UPPER RIO XINGÚ IN CENTRAL BRAZIL. By *George Sprague Myers* and *Antenor Leitão de Carvalho*..... 148

ICHTHYOLOGICAL NOTES

The cranial anatomy of a free-living pomacentrid "cyclopean". By *Edward M. Nelson*..... 152
A case of "schooling" behavior in the prickly sculpin, *Cottus asper* Richardson. By *T. G. Northcote* and *G. F. Hartman*.... 156
A Caribbean chaetodont fish, *Chaetodon aya* Steindachner, now referred to *Chaetodon aya* Jordon. By *George S. Myers*.. 158
Observations on *Pterois volitans* (L.) and its venom. By *H. Steinitz*..... 158
A pelagic record of the snipefish, *Macrorhamphosus scolopax* (L.) in the Gulf of Maine. By *David Miller*..... 160
Age, growth, and food of the longnose dace, *Rhinichthys cataractae*, in northwestern Pennsylvania. By *Roger J. Reed*..... 160
Parasitic lampreys (*Ichthyomyzon*) from the Missouri River, Missouri and South Dakota. By *Reeve M. Bailey*..... 162
Tricaine methanesulfonate (M.S. 222) as an anesthetic for the sea lamprey, *Petromyzon marinus*. By *Thomas B. Thorson*.. 163
Slime production in *Myxine glutinosa* Linnaeus. By *Ronald Strahan*..... 165
*Cypselurus luetkeni* (Jordon and Evermann) a synonym of *Cypselurus heterurus* (Rafinesque)? By *Victor G. Springer*..... 166

HERPETOLOGICAL NOTES

The relation of the fall line to the distribution and abundance of turtles. By *Donald W. Tinkle*..... 167
Amphibians and reptiles of the Thousand Islands Region, New York. By *William E. Werner, Jr.*..... 170
New localities for *Lichanura roseofusca gracia* in Inyo County, California. By *Frederick B. Turner*..... 172
*Xantusia v. vigilis* in Death Valley National Monument, California. By *Frederick B. Turner*..... 172
A study of movement of American toads in a Minnesota bog. By *Edward D. Bellis*..... 173
Studies on the orientation of turtles. By *Edwin Gould*..... 174
An instance of blood-squirting by *Phrynosoma solare*. By *William L. Cutler*..... 176
Blood protein and mineral chemistry in frog red leg disease. By *L. V. Gibbons* and *H. M. Kaplan*..... 176
The hellbender, *Cryptobranchus alleganiensis*, in Illinois. By *Hilda A. Stein* and *Philip W. Smith*..... 178

Reviews and Comments..... 179

Editorial Notes and News..... 184

FUTURE MEETINGS: Chicago Natural History Museum, Chicago, Illinois. June, 1960; University of Texas, Austin, Texas. April, 1961; U. S. National Museum, Washington, D. C. June, 1962.

Published quarterly by the American Society of Ichthyologists and Herpetologists, 34th St. and Girard Ave., Philadelphia 4, Pa. Second class postage paid at Philadelphia, Pa. and at additional offices.

1959 No. 2 COPEIA July 24

# Skin and Lung Capillaries in European Common Newts

Juliusz Czopek

MORPHOLOGICAL studies on the vascularization of respiratory surfaces in amphibians have shown considerable differences existing among species in the intensity of vascularization of the skin, lungs, and mouth, as well as in the length of capillaries vascularizing each of these surfaces per gram of body mass. In some species the number of lung capillaries predominates over that of the skin, while in others the number per gram of body mass is nearly the same (*Bombina bombina*, metamorphosed individuals of *Ambystoma mexicanum*). In small species the skin contains the majority of all respiratory capillaries (*Leiopelma hochstetteri, Triturus cristatus, T. alpestris*). In the early developmental stages of amphibians, the skin contains the greater number of respiratory capillaries. The mouth in most of the amphibians investigated constituted hardly 1 percent of all respiratory capillaries (Czopek and Szarski, 1954; Czopek, Pugaczewska, and Sopoćko, 1954; Czopek, 1955; Czopkowa and Czopek, 1955; Broda, 1956; Strawiński, 1956; Czopek, 1957). It may be surmised that the vascularization of respiratory surfaces in *Triturus vulgaris* is similar to that in *T. cristatus* and *alpestris*. In the breeding season the richly vascularized tail-fin, particularly well developed in males, could be expected to produce an increase of the role of gas-exchange through the skin.

This supposition is confirmed by the investigations carried out by Bannikov (1948), who examined the survival ability of breeding and normal specimens of *T. vulgaris* and *cristatus* placed in water and deprived of atmospheric oxygen. His experiments showed that breeding specimens were able to survive in water longer than non-breeding ones and that males survived longer than females.

The aim of the present study was to investigate the vascularization of respiratory surfaces in breeding and non-breeding specimens of *T. vulgaris*.

## Material and Methods

The 45 specimens of *T. vulgaris* used were collected in the environs of Toruń. Twenty-six were in full breeding dress, the remaining 19 were not. The vascularization of the respiratory surfaces was examined in detail in 10 specimens after they were injected with Prussian blue through the truncus arteriosus and fixed in 10 percent formalin. The methods of preparing tissues have been discussed in detail in the papers mentioned above.

Of the remaining 35 specimens, three males in full breeding dress and three devoid of it were used for histological sections of skin stained with eosin and haematoxylin. Two breeding and two normal males were used to determine content of body water. The specimens, after being killed and weighed, were desiccated at a temperature of about 100°C.

The remaining 25 specimens were used in a series of subsidiary physiological experiments aimed at the investigation of the quantity of $CO_2$ given off by breeding and non-breeding individuals. The specimens were placed in a hermetically closed, glass chamber 15 cm. x 10 cm. x 18 cm. and provided with a thermometer. The chamber was immersed in water which was maintained at 20°C. by means of a Höppler's thermostat. The air introduced into the experimental chamber was passed through two glass bottles containing 150 cc. of 5 N KOH each to eliminate $CO_2$. The $CO_2$ in the air leaving the chamber was absorbed in three bottles containing 150 cc. of about N/10 $Ba(OH)_2$ each. The titer of $Ba(OH)_2$ was determined by means of N/10 HCl in the presence of phenolphthalein before each experiment. Ten or 15 nearly equal-sized specimens were closed in the chamber at a time. The breeding specimens were in water 15 cm. deep. The non-breeding specimens were in a chamber filled with air. Before each experiment the animals were kept for two hours in the experimental chamber which was supplied with air deprived of $CO_2$. After that time the absorbing bottles with $Ba(OH)_2$ were attached for a space of four hours, after which time the contents of the bottles were titrated with N/10 HCl in the presence of phenolphthalein. From the differences in concentration of $Ba(OH)_2$ before and after the experiment, the amount of $CO_2$ given off by the animals per hour per gram of body mass was calculated.

## Structure of the Skin

The skin of breeding specimens of *Triturus vulgaris* shows some essential differences in

structure. It is smooth and the epidermis is composed, on the average, of three cell layers with a relatively great quantity of cytoplasm and rather large nuclei which are not so easily stainable in Delafield's haematoxylin as the same nuclei in other specimens. The surface of the epidermis is little cornified. The thickness of the epidermis averages 20$\mu$, that of the corium 69$\mu$. The mean number of glands in 1 mm.$^2$ of skin is 25, their diameter ranges from 15$\mu$ to 58$\mu$. The distribution of glands is not uniform. The skin of normal specimens is coarse owing to numerous minute warts on the surface of the epidermis, each of which is composed of 3 to 5 layers of epidermal cells. The epidermis consists, on the average, of 4 layers of cells with nuclei smaller in size, more flattened in shape, and more intensely colored than in breeding specimens. The outer layer of the epidermis is markedly cornified.

TABLE 1

| Weight and sex of specimens (Full breeding dress) | 2.70 g. ♂ | 2.50 g. ♂ | 2.40 g. ♂ | 1.50 g. ♂ | 2.05 g.* ♀ | 1.40 g.† ♀ |
|---|---|---|---|---|---|---|
| **Skin** | | | | | | |
| Surface in mm.$^2$ | 2,780 | 2,680 | 2,650 | 1,790 | 2,030 | 1,360 |
| Number of meshes of capillary-net per 1 mm.$^2$ | 41.1 | 37.3 | 37.1 | 35.0 | 38.5 | 41.0 |
| Length of capillaries in meters per 1 g. of weight of body | 13.035 | 13.100 | 13.449 | 14.129 | 12.289 | 12.434 |
| **Lungs** | | | | | | |
| Surface in mm.$^2$ | 178 | 170 | 164 | 120 | 158 | 122 |
| Number of meshes of capillary-net per 1 mm.$^2$ | 529 | 539 | 502 | 506 | 554 | 493 |
| Length of capillaries in meters per 1 g. of weight of body | 3.033 | 3.158 | 3.061 | 3.600 | 3.628 | 3.869 |
| **Palate** | | | | | | |
| Surface in mm.$^2$ | 40 | 37 | 37 | 27 | 35 | 26 |
| Number of meshes of capillary-net per 1 mm.$^2$ | 32 | 30 | 31 | 29 | 31 | 29 |
| Length of capillaries in meters per 1 g. of weight of body | 0.167 | 0.162 | 0.171 | 0.194 | 0.190 | 0.200 |

* Weight of ripe ovaries subtracted from total of 2.450 g.
† Weight of ripe ovaries subtracted from total of 1.640 g.

The epidermis averages 25.5$\mu$ in thickness, the corium 83$\mu$. The number of glands in 1 mm.$^2$ of skin averages 33, their diameter ranges from 13$\mu$ to 75$\mu$.

The pronounced increase in amount of glands in 1 mm.$^2$ of skin, as well as the thickening of the epidermis, is, no doubt, an adaptation of the organism to change from aquatic to terrestrial habitats; and its function is to protect the animal against excessive drying. The breeding specimens are characterized by high body-water content which attains nearly 83 percent. In non-breeding specimens, 76 percent of the animal's weight is water.

The increased thickness and callosity of the epidermis in normal specimens is probably unfavorable to cutaneous respiration.

### VASCULARIZATION OF THE SKIN

The vascularization of the skin in *T. vulgaris*, as in other salamanders, is distinguished from that in the Salientia by its lack of special arteries and veins exclusively for the supply of the skin. It is accomplished by the local arteries and veins. The skin capillaries form a network composed of rather regular polygonal meshes. In both breeding and non-breeding specimens, the dorsal side of the body is somewhat more intensely vascularized than the ventral side, and the capillaries of the tail-fin form markedly elongated meshes, which run almost parallel to one another and perpendicular to the long axis of the fin.

The number of meshes in 1 mm.$^2$ of skin for breeding specimens ranges from 35.0 to 41.1, whereas non-breeding specimens have 41.4 to 43.0 meshes in the same area (Tables 1 and 2). The diameter of the capillaries in normal specimens varies from 10$\mu$ to 18$\mu$. In breeding specimens it is nearly ¼ more.

In spite of the fact that the skin capillary network is somewhat less developed in breeding specimens, the length of capillaries per one gram of body mass in these specimens exceeds considerably that in non-breeding ones. The breeding males have more capillaries per gram of body mass than breeding females. The respective figures are: 13.035 m./g. to 14.129 m./g. and 12.289 m./g. to 12.434 m./g. With non-breeding specimens there is almost no sexual difference in length of skin capillaries per gram of body mass, ranging from 11.279 m./g. to 11.662 m./g. The considerable length of capillaries per gram of body mass in breeding specimens, in spite of the lesser density of the capillary network, is explained by the more favorable relation of body surface to body mass in these specimens than in non-breeding ones. The corresponding values are 10.88 for breeding males, 9.82 for breeding females, and 8.80 for other specimens.

### Vascularization of the Lungs

There are no essential differences in structure and vascularization of the lungs between the breeding and non-breeding *T. vulgaris*. The lungs of specimens investigated are elongated sacs slightly narrowing toward the posterior part of the body. They are devoid of septa which considerably increase the lung respiratory surface of the Salientia. The lung capillaries form a network, its density depending on the region of the lung. The most dense network occurs in the floor of the lung. In our specimens the lung capillary network averages from 484 to 554 meshes in 1 mm.², and the diameter of the capillaries varies from 7$\mu$ to 20$\mu$. The length of lung capillaries per gram of body mass ranges from 3.033 m. to 3.869 m. in breeding specimens and from 3.741 m. to 3.840 m. in non-breeding specimens (Tables 1 and 2). When the lungs are filled with air, it may be observed that they are far less extensible than those of the tailless amphibians. The lungs of breeding specimens are a little smaller relative to body size than the lungs of other specimens. The ratios of lung surface in cm.² to body mass in grams is 0.74 in the former and 0.84 in the latter.

### Vascularization of the Mouth

No essential differences in the vascularization of the mucous membranes of the mouth were noted between the normal and breeding specimens of *T. vuigaris*. The palatal capillaries often have a wavy course and form a network of various-sized meshes. The capillary walls are almost devoid of diverticulae which increase the respiratory surface of vessels in most of the Salientia.

The number of meshes in 1 mm.² of the palatal mucous membrane varies from 29 to 32, and the diameter of the capillaries ranges from 11$\mu$ to 23$\mu$. The length of these capillaries per gram of body mass varies from 0.162 m. to 0.233 m., a negligible quantity as compared with the skin and lung capillaries (Tables 1 and 2).

### Physiological Experiments

The physiological experiments showed no significant differences in the quantity of eliminated $CO_2$ between the breeding and non-breeding *T. vulgaris*. The breeding males give off from 0.0484 to 0.0567 cc. of $CO_2$ an hour per gram of body mass; other males, 0.0452 to 0.0598 cc. (Table 3). The breeding females give off from 0.0700 to 0.0708 cc., other females 0.0515 to 0.0628. Similar results were obtained for some Salientia by Bohr (1900) and Dolk and Postma (1927). It must be noted, however, that the breeding females were much more active throughout the experiment than the males, and this is probably the cause of their greater elimination of $CO_2$.

Table 2

| Weight and sex of specimens (Without breeding dress) | 1.50 g. ♂ | 1.50 g. ♂ | 1.32 g. ♂ | 1.80 g.* ♀ |
|---|---|---|---|---|
| **Skin** | | | | |
| Surface in mm.² | 1,330 | 1,320 | 1,140 | 1,600 |
| Number of meshes of capillary-net per 1 mm.² | 41.4 | 42.8 | 42.6 | 43.0 |
| Length of capillaries in meters per 1 g. of weight of body | 11.411 | 11.510 | 11.279 | 11.662 |
| **Lungs** | | | | |
| Surface in mm.² | 128 | 130 | 110 | 145 |
| Number of meshes of capillary-net per 1 mm.² | 506 | 484 | 515 | 539 |
| Length of capillaries in meters per 1 g. of weight of body | 3.840 | 3.815 | 3.783 | 3.741 |
| **Palate** | | | | |
| Surface in mm.² | 31 | 31 | 28 | 35 |
| Number of meshes of capillary-net per 1 mm.² | 32 | 30 | 30 | 31 |
| Length of capillaries in meters per 1 g. of weight of body | 0.233 | 0.226 | 0.232 | 0.216 |

* Weight of ripe ovaries subtracted from total of 1.95 g.

The results indicate that, provided the animals are relatively quiet during the experiment, no great differences in quantity of $CO_2$ eliminated can be observed between breeding specimens in water and non-breeding individuals on land.

The physiological experiments were regarded as subsidiary, as the method used for determination of $CO_2$ was not highly accurate. A complete elimination of $CO_2$ from $Ba(OH)_2$ and from the experimental chamber was very difficult to obtain. Nor does the method of determining $CO_2$ by titration assure the precise moment of neutralization of the solution.

However, the results obtained suggest no essential differences in intensity of metabolism between the specimens investigated.

TABLE 3

| Number and sex of investigated specimens | Date of experiment | Average weight of specimen | Quantity of $CO_2$ in cc. eliminated by the investigated newts in 4 hours | Quantity of $CO_2$ in cc. eliminated by one specimen in 1 hour | Quantity of $CO_2$ in cc. per 1 g. of body mass per 1 hour | Remarks |
|---|---|---|---|---|---|---|
| Specimens with breeding dress | | | | | | |
| 10 ♂ | 31.V. | 1.74 g. | 3.9200 | 0.0980 | 0.0563 | |
| 10 ♂ | 31.V. | 1.74 g. | 3.3710 | 0.0843 | 0.0484 | |
| 15 ♂ | 5.VI. | 1.74 g. | 4.4680 | 0.0745 | 0.0428 | |
| 15 ♂ | 5.VI. | 1.74 g. | 5.9240 | 0.0987 | 0.0567 | |
| 10 ♂ | 6.VI. | 1.74 g. | 4.2440 | 0.1061 | 0.0609 | |
| 10 ♂ | 6.VI. | 1.74 g. | 3.5280 | 0.0882 | 0.0507 | |
| 10 ♂ | 7.VI. | 1.74 g. | 3.9200 | 0.0980 | 0.0563 | |
| 10 ♀ | 8.VI. | 1.72 g. | 4.8160 | 0.1204 | 0.0700 | More active than the males |
| 10 ♀ | 8.VI. | 1.72 g. | 4.8720 | 0.1218 | 0.0708 | More active than the males |
| Specimens without breeding dress | | | | | | |
| 10 ♂ | 24.VII. | 1.24 g. | 2.8890 | 0.0722 | 0.0582 | |
| 10 ♂ | 24.VII. | 1.24 g. | 2.2400 | 0.0560 | 0.0452 | |
| 10 ♂ | 25.VII. | 1.24 g. | 2.9680 | 0.0742 | 0.0598 | |
| 10 ♂ | 26.VII. | 1.24 g. | 2.7320 | 0.0683 | 0.0551 | |
| 10 ♂ | 26.VII. | 1.24 g. | 2.9560 | 0.0739 | 0.0596 | |
| 10 ♀ | 27.VII. | 1.30 g. | 2.6760 | 0.0669 | 0.0515 | |
| 10 ♀ | 27.VII. | 1.30 g. | 3.2480 | 0.0812 | 0.0625 | |
| 10 ♀ | 28.VII. | 1.30 g. | 3.2700 | 0.0817 | 0.0628 | |
| 10 ♀ | 31.VII. | 1.30 g. | 2.8560 | 0.0714 | 0.0549 | |

## DISCUSSION OF RESULTS

Breeding and non-breeding specimens of *T. vulgaris* show considerable differences in skin structure. The thickness of the epidermis in the breeding males averages 20$\mu$, that of the corium 69$\mu$. The average number of glands in 1 mm.$^2$ of skin is 25. Corresponding values for the normal specimens average ⅕ higher. However, breeding specimens are characterized by a high body-water content, amounting to 83 percent as compared to 76 percent in non-breeding specimens. No significant differences in intensity of the vascularization of the lungs and mouth were observed in this investigation.

The skin capillary network is not as well developed in breeding specimens (from 35.0 to 41.1 meshes in 1 mm.$^2$ of skin) as in non-breeding specimens (41.4 to 43.0 meshes in 1 mm.$^2$). Nevertheless, the amount of capillaries per gram of body mass is larger in breeding specimens. This is accounted for by the ratio of body surface to body mass which is much more favorable for breeding salamanders (Table 4). Their body surface, particularly that of males, greatly increases as a result of the development of a large, richly vascularized tailfin. Thus, the skin capillaries in males are from 13.035 m./g. to 14.129 m./g., and in females, from 12.282 m./g. to 12.434 m./g. The quantity of skin capillaries in non-breeding specimens is about the same in males and females, ranging from 11.279 m./g. to 11.662 m./g. The diameter of the skin capillaries in breeding specimens is 25 percent larger than in non-breeding salamanders.

These data show that in *T. vulgaris* the role of the skin as a respiratory organ considerably increases during the breeding season; and the epidermis, having become thinner and less horny, permits penetration of oxygen through the skin. The thick, horny epidermis and the decreased skin capillaries per gram of body mass makes the role of the skin in gas exchange less important in non-breeding salamanders. The lungs of breeding specimens are correspondingly a little smaller in relation to body size.

The above statements explain why in the experiments of Bannikov (1948) the breeding males of *T. vulgaris*, deprived of atmospheric oxygen, survived in water over 96 hours, the breeding females over 80 hours, while other specimens under the same conditions survived hardly a few hours. Similar, though somewhat lower, data were obtained by this author for *T. cristatus*. The increase of the respiratory role of the skin is an adaptation to a more active life, particularly of males, in the breeding season. Among the Salientia an example of a considerable increase of the respiratory function of the skin in the breeding season is to be seen in the male of *Astylosternus robustus*. During the breeding season numerous strongly vascularized "hairs" appear on the posterior part of the back and on the thighs (Noble, 1925).

The lengths of capillaries vascularizing the respiratory surfaces in *T. vulgaris* expressed in percentages are as follows: in breeding males the skin capillaries constitute nearly 80 percent and the lung capillaries only 19 percent of all respiratory capillaries, in females the skin capillaries constitute nearly 76 percent and the lung capillaries about 23 per-

TABLE 4

| Specimen | Thickness of epidermis in μ | Ratio of surface of skin (in cm.²) to body mass (in g.) | Length of skin capillaries in meters per 1 g. of body weight | Length of capillaries of respiratory surfaces expressed in percent of total | | | Length of capillaries of all respiratory surfaces per 1 g. of body weight in meters | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | Skin | Lungs | Palate | | |
| *T. vulgaris* | 20.0 | 10.88 | 13.428 | 79.86 | 19.11 | 1.03 | 16.814 | Males in full breeding dress |
| *T. vulgaris* | 24.0 | 9.82 | 12.362 | 75.82 | 22.99 | 1.19 | 16.305 | Females in full breeding dress |
| *T. vulgaris* | 25.5 | 8.80 | 11.465 | 74.03 | 24.50 | 1.47 | 15.487 | Specimens without breeding dress |
| *T. cristatus* | 25.0 | 5.84 | 11.666 | 73.70 | 23.30 | 3.00 | 15.570 | Specimens without breeding dress |
| *T. alpestris* | 25.4 | 5.74 | 11.410 | 75.61 | 22.79 | 1.60 | 15.090 | Specimens without breeding dress |

In *T. cristatus* the capillaries were counted both in the palate and in the floor of the mouth.

cent (Table 4). No noticeable differences in the vascularization of respiratory surfaces are shown by non-breeding males and females. In both, the skin capillaries constitute 74 percent, and the lung capillaries 24.5 percent of all respiratory capillaries. Respiration through the mouth is certainly of no great importance in gas exchange as the capillaries of the mucous membrane of the palate constitute only a little over one percent of respiratory capillaries. Even assuming that the gular movements can continually ventilate the mouth cavity and increase the gas exchange through mouth capillaries by five times, only 15 percent of gas exchange will take place in the mouth cavity.

According to the physiological experiments the quantity of $CO_2$ given off by specimens of *T. vulgaris* per gram of body mass at 20°C. is nearly the same for breeding specimens in water as for other specimens on land (Table 3). The results of the physiological experiments, however, do not prove complete uniformity of metabolic rate under natural conditions. The conditions to which the animals were subjected during the experiments were far from natural. Moreover, the animals were mostly at rest and the sexes were separated which, no doubt, reduced the quantity of $CO_2$ given off, especially by the breeding males. Nor was the method used to determine $CO_2$ perfectly accurate. A higher metabolism level during the breeding season does result as shown by Miller and Wurster (1957). According to them the blood glucose level in *Taricha torosa* averages 15–20 mg. percent in non-breeding animals while in breeding individuals it is 25–35 mg. percent.

## SUMMARY

The vascularization of the respiratory surfaces in breeding and normal specimens of *T. vulgaris* has been investigated and the lengths of skin, lung, and palatal capillaries have been calculated.

In the breeding males there are from 13.035 m. to 14.129 m. of skin capillaries and from 3.033 m. to 3.600 m. of lung capillaries per gram of body mass. This means that nearly 80 percent of all respiratory capillaries are situated in the skin and 19 percent in the lungs.

The breeding females have from 12.289 m./g. to 12.434 m./g. of skin capillaries and from 3.628 m./g. to 3.869 m./g. of lung capillaries, i.e., the amount of skin capillaries averages about 76 percent, that of lung capillaries nearly 23 percent of the total amount of respiratory capillaries.

The length of respiratory capillaries in both sexes outside the breeding season is much the same. This ranges from 11.279 m./g. to 11.662 m./g. of skin capillaries and from 3.741 m./g. to 3.840 m./g. of lung capillaries per gram of body mass. Seventy-four percent of the total amount of respiratory capillaries is then constituted by skin capillaries and 24.5 percent by lung capillaries.

Respiration through the mouth is of little

importance in gas exchange, as the capillaries of the mucous membranes of the palate in both breeding and non-breeding specimens are only a little over one percent of the total amount of respiratory capillaries.

The intensification of the vascularization of the skin in the breeding specimens of *T. vulgaris* indicates the possibility of a rise in metabolism during the breeding season, particularly in males.

### Literature Cited


Bannikov, A. G. 1948. O sezonnom izmenenii dychatel' noj funkcii koži u tritonov. *Doklady A.N. S.S.S.R. 59: 1121–4.*

Bohr, Ch. 1900. Über die Haut und Lungenatmung der Frösche. *Skand. Arch. f. Physiol. 10: 74.*

Brodowa, G. 1956. Unaczynienie powierzchni oddechowych traszki górskiej (*Triturus alpestris* Laur.). *Studia Soc. Sci. Torunensis, Sec. E. 3: 85–93.*

Czopek, J. 1955. The vascularization of the respiratory surfaces of some Salientia. *Zool. Pol. 6: 101–34.*

———. 1955. Vascularization of respiratory surfaces in *Leiopelma hochstetteri* Fitzinger and *Xenopus laevis* (Daudin). *Acta Anat. 25: 346–60.*

———. 1957. The vascularization of respiratory surfaces in *Ambystoma mexicanum* (Cope) in ontogeny. *Zool. Pol. 8: In Press.*

Czopkowa, G., and J. Czopek. 1955. The vascularization of the respiratory surfaces in *Bombina variegata* (L.). *Bull. Acad. Pol. Sci. Cl. II, 3: 313–18.*

Czopek, J., H. Pugaczewska, and I. Sopoćko. 1954. Unaczynienie powierzchni oddechowych u traszki grzebieniastej (*Triturus cristatus* Laur.). *Folia Morph. 5: 93–104.*

Czopek, J., and H. Szarski. 1954. Oddychanie skorne plazow i jego konsekwencje ewolucyjne. *Kosmos 3: 256–67.*

Dolk, H. E., and N. Postma. 1927. Über die Haut und Lungenatmung von *Rana temporaria. Ztschr. Vergl. Physiol. 5: 417–44.*

Miller, M. R., and D. H. Wurster. 1957. Studies on the carbohydrate metabolism of the salamander, *Taricha torosa. Anat. Rec. 128: 590.*

Noble, G. K. 1925. The integumentary, pulmonary and cardiac modifications correlated with increased cutaneous respiration in the amphibia: A solution of the "hairy frog" problem. *Jour. Morph. and Physiol. 40: 341–416.*

Strawiński, S. 1956. Vascularization of respiratory surfaces in ontogeny of the edible frog, *Rana esculenta* L. *Zool. Pol. 7: 328–65.*


Department of General Zoology, Copernicus University, Toruń, Poland.

# Amphibians and Reptiles from the Pleistocene (Illinoian) of Williston, Florida

J. Alan Holman

### Introduction

Vertebrate fossils from the vicinity of Williston, Florida, have been known for some time (Leidy, 1896), but considerable confusion has resulted because the early collectors mixed faunas of Pliocene and Pleistocene age (Simpson, 1929). Recently a new Pleistocene fauna was discovered at Williston in the Connell and Shultz Limerock Company mine by Dr. Pierce Brodkorb of the Department of Biology of the University of Florida. The large herpetofauna of this locality forms the subject of the present paper.

The site is situated in Levy County just within the north city limits of Williston, Florida. It has an approximate elevation of 82 feet, lying east of State Road 331 and Florida Geodetic Survey marker H 79 (Gunter, 1948). It is located in area 4-2 of the Williston quadrangle (U. S. Geological Survey, 1950) and is 0.9 miles north of the Seaboard Air Line Railroad station in Williston.

The Williston area exhibits typical Karst topography, with many depressions and sinks. The vegetation around the fossil locality, although modified by man, is of a mesophytic derivation.

The bones were deposited in a clay and sand-filled solution pipe in the Crystal River formation of the Ocala group (Puri, 1953). Cooke (1945) discusses pipe formation thus: "The free circulation of water through the Ocala limestone has facilitated the solution of the rock. Funnel-shaped cavities, most of them filled with clay and sand and some containing bones, lead downward from the surface and connect with ramifying underground passages." The removal of overlying sediments during limestone operations frequently reveals these clays unconformably overlying the Eocene Crystal River limestone.

Such pockets are dug out by hand by employees of limestone companies and the clay and sand hauled and bulldozed away as quarrying is extended laterally. The sink containing the fossils had thus been partially excavated when it was discovered.

The sink was about 15 feet in diameter in a north-south direction. The east face of the sink was covered by partially weathered original material. When this matrix was excavated two small caverns were exposed, connected by a small crevice about six inches high. One cavern was a foot high, three feet in width, and extended horizontally only about one and one-half feet into the limestone. The other cavern was about three feet high, six feet wide, and extended about three feet horizontally before turning downward as part of the apex of the solution funnel. The sediments in the sink consisted of yellow-brown clays, bluish sandy clays, and some stratified layers of sand, indicating that at least several years were required for the fossils and sediments to be deposited. The majority of the bones occurred in the yellow-brown clays, with the bluish sandy clay also yielding some specimens.

A typical fossil bone from Williston matrix is a light yellowish brown color, but individual bones range in color from white, mottled with black, to very dark red-brown. The bones are well mineralized and become fairly brittle when they are thoroughly dry.

Overlying the clay-filled sinks is the Wicomico terrace sand, which has a characteristic dull orange color. This marine terrace was deposited during the Sangamon interglacial stage which followed the Illinoian glacial stage (Cooke, 1945). Brodkorb (1957) has indicated that the Reddick, Florida, vertebrate locality represents the Illinoian stage because of its location in respect to the Wicomico terrace. It is also to this stage to which the Williston site is here referred. A good exposure of the Wicomico terrace is seen on the east side of the mine. Other fossil localities, underlying the Wicomico terrace and apparently representing the Illinoian stage, are found at Arredondo, Kanapaha, and Haile, Florida.

Excavations were carried out from May through September of 1956. Both caverns were excavated and also most of the material from the crevice connecting them. The sink itself was excavated to a depth of eight feet, when the locality was destroyed by mining operations.

Matrix was brought to the laboratory, where it was washed in a screen until the clay and sand had filtered through. Larger bones were picked from the matrix, and pebbles and other debris discarded. The resulting material was examined under the dissecting microscope for smaller fossils. The fossils reported herein have been deposited in the collection of the Florida Geological Survey.

I wish to express my thanks to the following people of the Biology Department of the University of Florida: to Dr. Pierce Brodkorb for his kind help in the direction of the M. S. thesis of which this paper is a part. To Dr. Walter Auffenberg for advice in the identification of the fossils and Dr. Pierce Brodkorb, Dr. James N. Layne, Dr. William J. Riemer, Howard Campbell, F. Wayne King, and Larry H. Ogren for the loan or gift of skeletal material.

### Fauna

All classes of vertebrates were well represented except fishes, of which only a single indeterminate vertebra was found. The associated fauna (those preceded by an asterisk are extinct forms) includes:

*Birds:*

*Anas discors*
**Colinus* sp.
*Meleagris gallapavo*
*Corvus brachyrhyncos*
*Corvidae sp.
Fringillidae sp.

*Mammals:*

*Scalopus aquaticus*
*Cryptotis parva*
*Blarina brevicauda*
*Ursus* sp.
*Lynx rufus*
*Sciurus carolinensis*
*Geomys pinetis*
*Peromyscus gossypinus*
*Oryzomys palustris*
*Sigmodon hispidus*
*Neotoma floridana*
**Pitymys* sp.
*Sylvilagus palustris*
*S. floridanus*
**Dasypus bellus*
**Tapirus veroensis*
**Mylohyus* sp.
*Odocoileus virginianus*
**Equus* sp.

## AMPHIBIA

### Caudata

*Ambystoma* Tschudi.—Material: Thirty precaudal vertebrae (FGS V-5782). The vertebrae of *Ambystoma* are very difficult to separate at the species level. Table 1 gives the

length (anterior to posterior zygopophyses) of the fossil *Ambystoma* vertebrae as compared to those of some Recent adult species of *Ambystoma*. The largest Recent species of *Ambystoma* occurring in eastern United States is *A. tigrinum*. Since 15 of the fossils are as large or larger than this species it may be that these vertebrae represent *A. tigrinum*. A species is not suggested for the smaller fossils.

TABLE 1

MEASUREMENTS (mm.) OF LENGTHS OF PRECAUDAL VERTEBRAE OF PLEISTOCENE AND RECENT *Ambystoma*

| Recent Adult *Ambystoma* | Range | Mean | No. of Specimens |
|---|---|---|---|
| *A. texanum* | 4.0–4.2 | 4.07 | 3 individuals |
| *A. talpoideum* | 3.1–3.6 | 3.35 | 3 " |
| *A. cingulatum* | 3.0–3.2 | 3.10 | 2 " |
| *A. tigrinum* | 4.9–5.3 | 5.10 | 2 " |
| Fossil *Ambystoma*: | | | |
| *A.* (?) *tigrinum* | 4.9–6.0 | 5.22 | 15 vertebrae |
| *A.* sp. indet. | 3.6–4.8 | 4.26 | 15 " |
| All Pleistocene *Ambystoma* | 3.6–6.0 | 4.75 | 30 vertebrae |

TABLE 2

MEASUREMENTS (mm.) OF ILIA OF *Bufo terrestris*

| | Recent | | | Fossil | | |
|---|---|---|---|---|---|---|
| | Range | Mean | No. | Range | Mean | No. |
| Greatest ht. anterior to iliac protuberance | 1.4–3.2 | 2.12 | 20 | 2.0–3.5 | 2.94 | 22 |
| Greatest ht. of acetabulum | 2.3–5.5 | 3.37 | 20 | 2.8–6.2 | 4.71 | 20 |
| Ht. from iliac protuberance through posteroventral expansion | 4.6–10.6 | 6.73 | 18 | 9.6–10.6 | 10.02 | 4 |

*Plethodon glutinosus* (Green).—Material: Fourteen vertebrae (FGS V-5783). A single vertebra of *P. glutinosus* has been reported from the Wisconsin stage of the Pleistocene of Citrus County, Florida (Holman, 1958).

ANURA

*Scaphiopus holbrooki* (Harlan).—Material: Ten right and nine left ilia (FGS V-5784). Auffenberg (1956*a*) reports the genus *Scaphiopus* from the Miocene of Florida and Holman (1958) reports the species from the Wisconsin of Citrus County, Florida.

*Bufo terrestris* (Bonnaterre).—Material: Fourteen right and 8 left ilia, 4 right and 7 left cranial crests (FGS V-5785). The fossil ilia average larger than those of 20 Recent *B. terrestris* (Table 2). The fossil cranial crests also appear much larger than those of the Recent *B. terrestris* studied, but because of the fragmentary condition of the fossils measurements were not taken.

*Hyla* Laurenti.—Auffenberg (1956*a*) has discussed some of the differences between the ilia of *Acris, Pseudacris,* and *Hyla*. In the identification of the *Hyla* fossil ilia, Recent skeletons of the following frogs were studied: *Acris gryllus, Pseudacris nigrita, Pseudacris ornata, Hyla crucifer, Hyla versicolor, Hyla phaeocrypta, Hyla cinerea, Hyla squirella, Hyla femoralis,* and *Hyla gratiosa*. Figure 1

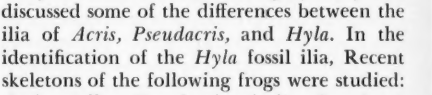



Fig. 1.—Right ilium drawn from *Hyla gratiosa* illustrating terminology in text. A, acetabular expansion acute dorsally; B, acetabular fossa; C, acetabular border; D, angle of acetabular expansion with shaft; F, shaft; G, dorsal prominence; H, dorsal protuberance.

is a right ilium drawn from *H. gratiosa* illustrating terminology used below.

In *Acris* the acetabular expansion is truncate or rounded ventrally, while in *Hyla* it is much more acute. In *Acris* the ventral acetabular expansion makes much less angle with the shaft than in *Hyla*. In *Acris* the area of the acetabular fossa is smaller, deeper, and has a much more extruded ventral border than in *Hyla*. *Pseudacris nigrita* resembles *Acris* in the above characters, while *Pseudacris ornata* resembles *Hyla*. The ilia of both species of *Pseudacris*, however, differ from both *Hyla* and *Acris* in that the dorsal prominence is more elevated from the shaft, causing the protuberance of the prominence to be a greater distance from the dorsal border of the acetabular cup. The acute angle of the dorsal acetabular expansion is also directed much more dorsad and anteriorad in *Pseudacris* than in either *Acris* or *Hyla*.

*Hyla femoralis* (Latreille).—Material: One left ilium (FGS V-5786). In *H. squirella* the dorsal protuberance is very small and is directed dorsad whereas in the fossil it is large and laterally directed. In *H. versicolor, cinerea,* and *phaeocrypta* the dorsal protuberance is much closer to the dorsal border of the acetabular fossa and much more oval than in the fossil. *Hyla gratiosa* is much larger than the fossil and the protuberance is more oval and dorsally directed. The relationships of the fossil seem to lie with *H. femoralis.* As Auffenberg (1956*a*) mentions, the dorsal protuberances in *H. crucifer* and some *H. femoralis* are more rounded than in other species of *Hyla.* In *H. femoralis* this rounding appears to be ontogenetic, for the small Recent ilia manifest oval protuberances while in the large ilia the protuberances are rounded. The fossil not only has the rounded protuberance but is the same size as the Recent *H. femoralis* exhibiting this condition. Although *H. crucifer* also has a rounded protuberance, as Auffenberg (*op. cit.*) points out, the protuberance is anterior to the acetabular fossa whereas in both the fossil and the Recent *H. femoralis* the protuberance is posterior to the acetabulum.

*Hyla* sp. indet.—Material: One left and one right ilium (FGS V-5787). The above ilia have rounded protuberances but are not assigned to species because the ventral acetabular expansions are broken in both specimens.

*Rana* Linnaeus.—Material: Six right and seven left ilia (FGS V-5788). Although the large dorsal crest on the ilium of *Rana* is diagnostic at the generic level, determining the species is extremely difficult. Both large and small fossil ilia are present from Williston indicating the existence of a large species such as *R. catesbeiana, grylio,* or *hecksheri,* and a small species such as *R. pipiens.* In studying Recent comparative material it was noticed that in most cases the dorsal angle of the acetabular expansion is more anteriorly directed in *R. pipiens, clamitans,* and *palustris* than in the *R. catesbeiana, grylio, hecksheri* group. Accordingly, the small fossils exhibited the anteriorly directed expansions while in the large fossils the expansions were more posteriorly directed.

*Microhyla carolinensis* (Holbrook).—Material: Three right and four left ilia (FGS V-5789). The genus *Microhyla* has been reported from the Miocene of Florida by Auffenberg (1956*a*), and the species *M. carolinensis* from the Wisconsin Stage of the Pleistocene of Citrus County, Florida, by Holman (1958).

## REPTILIA

### Crocodilia

*Alligator mississipiensis* (Daudin).—Material: Partial maxilla, five isolated teeth, two partial vertebrae, three dermal scutes (FGS V-5790).

### Squamata

#### Sauria

*Anolis carolinensis* Voigt.—Material: Two rights and one left dentary (FGS V-5791). The number of teeth on the complete right dentary was 20, falling within the range of specimens of *A. carolinensis* (Auffenberg, 1956*b*). The two other dentaries were fragmentary.

*Ophisaurus ventralis* (Linnaeus).—Material: One vertebra (FGS V-5792). Auffenberg (1955) discusses characters that distinguish the vertebrae of *O. ventralis, compressus,* and *attenuatus.* The above vertebra fits into the range of *O. ventralis.*

*Ophisaurus* sp. indet.—Material: Four vertebrae (FGS V-5793). One of the above vertebrae is fragmental. The other three which represent small glass lizards barely fit into Auffenberg's (*op. cit.*) centrum length-width ratios for *Ophisaurus compressus.* Since so much ontogenetic variation has been noted in reptile skeletons and small Recent specimens of *Ophisaurus* are not available the above vertebrae are not assigned to species.

*Eumeces* cf. *Eumeces inexpectatus* Taylor.—Material: Right dentary (FGS V-5794). The fossil dentary from Williston has a tooth count of 24, within the range of both *E. laticeps* and *inexpectatus* (Auffenberg, 1956*b*). Because of its small size it is provisionally referred to the latter species.

*Rhineura floridana* (Baird).—Material: Six thoracic vertebrae (FGS V-5795). Holman (1958) has reported three posterior vertebrae of *R. floridana* from the Wisconsin stage of the Pleistocene of Citrus County, Florida. An ontogenetic condition of the vertebrae in *R. floridana* exists that might lead to confusion in their identification. In large specimens the neural arch of thoracic vertebrae has several pronounced ridges on its posterior half. The posterior border of the neural arch (including the posterior aspect of the neural spine in more anterior thoracics) shows very pronounced knob-like protuberances in large worm lizards. In small specimens the posterior

neural ridges are visible only with excellent lighting and the neural spine does not possess the knob-like protuberances found in large specimens, but is sinuate in appearance. The fossils represent a large individual or individuals.

SERPENTES

*Rhadinaea flavilata* (Cope).—Material: One vertebra (FGS V-5796). In vertebral characters the genera *Rhadinaea* and *Diadophis* are extremely close. The character with the least overlap is found in the neural spine. In eleven Recent *Rhadinaea* skeletons studied it projects in dorsal aspect well beyond the posterior border of the neural arch. Only four of 17 Recent *Diadophis* skeletons exhibit this condition and they are large specimens. Five show very slight projections and eight have no projections at all. The fossil is smaller than any of the *Diadophis* having the projection, yet its neural spine extends well beyond the neural arch.

*Diadophis punctatus* (Linnaeus).—Material: Five vertebrae (FGS V-5797). These small vertebrae represent *Diadophis* as the neural spines do not project beyond the posterior border of the neural arch.

*Heterodon platyrhinos* Latreille.—Material: Two vertebrae (FGS V-5798). The best character for separating the species *H. platyrhinos* from *H. simus* is in the haemal keel. In *H. platyrhinos* the haemal keel is constricted in the region of the paradiapophyses. In *H. simus* the haemal keel is uniform in width. The haemal keel of *Heterodon* is the broadest and lowest of any medium-sized colubrid snake I have examined.

*Heterodon simus* Linnaeus.—Material: Six vertebrae (FGS V-5799).

*Coluber constrictor* Linnaeus.—Material: Four vertebrae (FGS V-5800).

*Masticophis flagellum* Shaw.—Material: One vertebra (FGS V-5801). Two vertebrae (FGS V-5802) may represent either *Coluber* or *Masticophis*.

*Drymarchon corias* Holbrook.—Material: Two vertebrae (FGS V-5823).

*Elaphe* sp. indet.—Material: Five vertebrae (FGS V-5803). The vertebrae of *Elaphe*, *Pituophis*, and *Lampropeltis* are very similar. *Pituophis* can be distinguished by its much higher neural spine. Brattstrom (1955*a*) mentions that in *Elaphe* the subcentral ridges are straight from below, while in *Lampropeltis* they are arched. In the skeletons examined by me this character shows considerable overlap. Six of thirteen *Elaphe* and two of 11 *Lampropeltis* were inseparable. Among the fossils the five vertebrae assigned to *Elaphe* sp. exhibit very straight subcentral ridges. One vertebra (FGS V-5804) is intermediate and is not assigned to genus.

*Pituophis melanoleucus* Daudin.—Material: Seven vertebrae (FGS V-5805).

*Thamnophis* cf. *Thamnophis sirtalis* (Linnaeus).—Material: One vertebra (FGS V-5806). Because of its large size and on geographic grounds this vertebra is tentatively assigned to the species *Thamnophis sirtalis*.

*Thamnophis* sp.—Material: Twelve vertebrae (FGS V-5807). These small vertebrae are not assigned to species.

*Micrurus fulvius* (Linnaeus).—Material: Five vertebrae (FGS V-5808).

*Sistrurus miliarius* (Linnaeus).—Material: Two vertebrae (FGS V-5809).

*Ancistrodon piscivorus* (Lacepede).—Material: Three vertebrae (FGS V-5810).

*Crotalus adamanteus* Beauvois.—Material: Eleven vertebrae (FGS V-5811). All of these vertebrae are clearly those of *C. adamanteus*. The giant extinct rattlesnake *C. giganteus* is not represented in the deposit.

TESTUDINATA

*Terrapene carolina* Linnaeus.—Material: Partial shell elements (FGS V-5812), two left, two right humeri, and two left femora (FGS V-5713).

Recent papers on fossil box turtles include those of Barbour and Stetson (1931), Milstead (1956), and Auffenberg (1958).

The Williston fossil box turtles seem to be intermediate between *T. c. bauri* and *T. c. major*, both found in Florida today. The fourth marginal scute lacks the axillary scale as in most *T. c. major*. The marginals are somewhat flared, intermediate between the condition in *bauri* and *major*. Measurements of individual scutes (Table 3) indicate that the fossils are larger than *bauri*, yet smaller than *major*. Measurements of *bauri* and *major* are given in Holman (1958). The long bones exhibit the same trend, being intermediate in size between the two forms (Table 4).

An ontogenetic change in the humeri was noted in both Recent and fossil *T. carolina*. In young turtles the head of the humerus is depressed; in mature individuals it becomes compressed.

*Pseudemys floridana* (LeConte).—Material: Nuchal bone (FGS V-5814). Separating young *Pseudemys* from *Deirochelys* is difficult because the shape of the nuchal bone is similar in the two genera. However, in *Deirochelys*

the nuchal bone usually does not incorporate any of the adjacent costal scutes, or at most only a very small corner. In *Pseudemys* a much larger part of the costal is incorporated in the nuchal bone.

*P. floridana* differs from *P. scripta* and *P. nelsoni* in that the nuchal scute is usually truncate and flat, and neither projects beyond nor is elevated above the adjacent marginals, and the whole nuchal bone is almost free of rugosity.

*Testudo* sp.—Material: Nuchal bones (FGS V-5815, V-5816, V-5817, V-5818, and V-5819), and three right humeri (FGS V-5820). Since the Williston *Testudo* material is the size of large *Gopherus* it would seem wise to point out characters to distinguish these forms.

Oelrich (1957) has shown that the nuchal scute in *Testudo* is much longer than wide, whereas in *Gopherus* it is wider than long. In the present material a character useful in separating the genera is that the nuchal indention is deeply V-shaped in *Testudo*, shallowly U-shaped in *Gopherus*.

The humeri of the two genera may be separated on the following characters: (1) ulnare process more robust in *Testudo* than in *Gopherus*; (2) dorsal angle between head and radial process much less in *Testudo* than in *Gopherus*; (3) distal end constricted with condyles rounded dorsoventrally in *Testudo*, expanded with angular condyles in *Gopherus*; (4) shaft in lateral view much more curved in *Testudo* than in *Gopherus*.

In the Florida Pleistocene Williams (1950) recognizes two species of *Testudo*, *Testudo sellardsi* Hay and *T. crassiscutata* Leidy. Both of these species are giant forms. Recently Milstead (1956) described a small tortoise from the Pleistocene of Texas under the name of *T. wilsoni*. The five nuchal bones from Williston agree in size with *T. wilsoni*, being much smaller than those of the giant species (Table 5). Unfortunately Milstead neither figured nor described the nuchal and humerus of his new species. It is therefore impossible to state at this time whether the Williston material represents *T. wilsoni*, the young of the giant species, or still another form. Loveridge and Williams (1957) suggest that the large Tertiary and Pleistocene tortoises of North America represent the genus *Geochelone* Fitzinger instead of *Testudo*.

*Gopherus polyphemus* (Daudin).—Material: Nuchal bone (FGS V-5821). The above nuchal is identical to Recent Florida *Gopherus polyphemus*.

*Amyda ferox* (Schneider).—Material: Left humerus (FGS V-5822). The humerus of the soft-shelled turtle is very distinctive. The very constricted head runs diagonally to the shaft and easily separates it from other genera.

TABLE 3

MEASUREMENTS (mm.) OF MARGINALS IN FOSSIL *Terrapene carolina* FROM WILLISTON, FLORIDA

| | Length | | Width | |
|---|---|---|---|---|
| | Range | No. | Range | No. |
| Marginal two | 22.2 | 1 | 20.7 | 1 |
| four | 18.7 | 1 | 21.2 | 1 |
| five | 23.7 | 1 | 27.0 | 1 |
| six | 20.2 | 1 | 22.4 | 1 |
| seven, | 24.6 | 1 | 20.8 | 1 |
| eight | 21.7–25.8 | 4 | 16.5–23.0 | 4 |
| nine | 20.0–22.2 | 4 | 18.0–20.2 | 4 |
| ten | 15.5–23.9 | 3 | 13.7–21.7 | 3 |
| eleven | 13.5–20.5 | 3 | 15.7–18.5 | 3 |

TABLE 4

MEASUREMENTS (mm.) OF LIMB ELEMENTS OF *Terrapene*

| | Fossil *T. carolina* | | Recent *T. c. bauri* | | Recent *T. c. major* | |
|---|---|---|---|---|---|---|
| | Range | No. | Range | No. | Range | No. |
| Humerus, length | 23.2–34.0 | 4 | 22.6–28.8 | 9 | 44.3 | 1 |
| Humerus, greatest proximal width | 10.5–12.0 | 4 | 7.5–9.3 | 9 | 13.5 | |
| Femur, greatest width of shaft | 4.7–5.8 | 2 | 2.8–4.3 | 9 | 6.2 | |

TABLE 5

MEASUREMENTS (mm.) OF NUCHALS OF WILLISTON *Testudo* sp.

| Specimen | Length | Width |
|---|---|---|
| FGS V-5815 | 34.5 | 46.0 |
| FGS V-5816 | 37.8 | — |
| FGS V-5817 | — | 53.4 |
| FGS V-5818 | 48.5 | 64.1 |
| FGS V-5819 | — | 67.7 |

No differences are found between the above humerus and those of the Recent *A. ferox*.

## DISCUSSION

In the light of Recent ecological preferences of Florida reptiles and amphibians the major ecological habitat at Williston was a

low, poorly drained pine flatwoods dotted with small cypress ponds. The following animals represented in the Williston fossil fauna are found in this association today: *Bufo terrestris, Hyla femoralis, Rana pipiens, Microhyla carolinensis, Ophisaurus ventralis, Eumeces inexpectatus, Rhadinaea flavilata, Diadophis punctatus, Coluber constrictor, Thamnophis sirtalis, Micrurus fulvius, Sistrurus miliarius, Ancistrodon piscivorus, Terrapene carolina, Pseudemys floridana,* and *Amyda ferox.* A nearby dry pine-palmetto flatwoods could support *Scaphiopus holbrooki, Heterodon simus, H. platyrhinos, Masticophis flagellum, Drymarchon corias, Pituophis melanoleucus, Crotalus adamanteus,* and *Gopherus polyphemus.* The latter association possibly was locally modified by limestone solution into an area of depressions and sinks (as it is today) and was likely surrounded by mesophytic vegetation, where *Ambystoma, Plethodon glutinosus, Rhineura floridana,* and *Elaphe* could live.

The similarity between the Williston Pleistocene herpetofauna and that found in the same area today is striking. Only one (*Testudo*) of 30 fossil amphibians and reptiles is extinct. All of the other members of the herpetofauna occur near Williston today. Moreover, several of the fossil mammals from Williston have different geographic affinities at present. These include: *Pitymys* sp. *Dasypus bellus, Tapirus, Mylohyus,* and *Equus.*

The composition of the fossil herpetofauna contrasts with that of the warm-blooded verterbates. Two of six fossil birds from Williston are extinct as are five of 19 mammals.

The stability of the Florida herpetofauna since the Illinoian stage of the Pleistocene is interesting in the light of the extinction of large mammals toward the end of this epoch. It would appear that climatic stresses would act on both warm and cold-blooded forms. I believe that something other than climatic change, possibly the rise of man was important in this differential in extinction between warm and cold-blooded vertebrates.

## Literature Cited


Auffenberg, W. 1955. Glass lizards (*Ophisaurus*) in the Pleistocene and Pliocene of Florida. *Herpetologica 11: 133–136.*

———. 1956*a*. Remarks on some Miocene anurans from Florida with a description of a new species of *Hyla. Mus. Comp. Zool. Breviora 52: 1–11.*

———. 1956*b*. Additional records of Pleistocene lizards from Florida. *Quart. Jour. Florida Acad. Sci. 19: 157–167.*

———. 1958. Fossil turtles of the genus *Terrapene* in Florida. *Bull. Florida State Mus. 3(2): 53–92.*

Barbour, T., and H. C. Stetson. 1931. A revision of the Pleistocene *Terrapene* of Florida. *Bull. Mus. Comp. Zool. 72: 295–299.*

Brodkorb, P. 1957. New passerine birds from the Pleistocene of Reddick, Florida. *Jour. Paleont. 31: 129–138.*

Carr, A. F. 1940. A contribution to the herpetology of Florida. *Univ. Florida Publ., Biol. Sci. Ser. 3(1): 1–118.*

Cooke, C. W. 1945. Geology of Florida. *Florida Geol. Surv., Geol. Bull. 29: 1–339.*

Gunter, H. 1948. Elevations in Florida. *Florida Geol. Surv., Geol. Bull. 32: 1–1158.*

Holman, J. A. 1958. The Pleistocene herpetofauna of Saber-tooth Cave, Citrus County, Florida. *Copeia 1958(4): 276–80.*

Loveridge, A., and E. E. Williams. 1957. Revision of the African tortoises and turtles of the sub-order Cryptodira. *Bull. Mus. Comp. Zool. 115(6): 153–557.*

Milstead, W. W. 1956. Fossil turtles of Friesenhahn Cave, Texas, with the description of a new species of *Testudo. Copeia. 1956(3): 162–171.*

Oelrich, T. H. 1947. The status of the upper Pliocene turtle *Testudo turgida* Cope. *Jour. Paleont. 31: 228–241.*

Puri, H. S. 1953. Zonation of the Ocala group in peninsular Florida. *Jour Sed. Petrology 23: 130.*

Simpson, G. G. 1929. The extinct land mammals of Florida. *Florida Geol. Surv., 20th Ann. Rept.: 229–280.*

Williams, E. E. 1950. *Testudo cubensis* and the evolution of western hemisphere tortoises. *Amer. Mus. Nat. Hist. Bull. 95: 1–36.*

Wright, A. H., and A. A. Wright. 1949. Handbook of frogs and toads. *Comstock Publ. Co., Ithaca. 640 pp.*


Department of Biology, University of Florida, Gainesville, Florida

# A Motion Picture Study of Maternal Behavior of the Lizard, *Eumeces obsoletus* Baird and Girard

Llewellyn T. Evans

MATERNAL behavior in lizards is usually limited to the deposition of eggs in a crevice, hollow log, or in a depression dug by the female herself or in one excavated by some other small creature. The choice of location will depend upon the ecological factors prevailing such as moisture, solar radiation, soil drainage, etc. Asana (1941) described the actual egg-laying habits of a female of a non-brooding species, *Calotes versicolor* (Boulenger). In the genus *Eumeces,* however, the female deposits her clutch in a burrow or in a hollow beneath a stone or other covering or in a hollow log; she then remains nearby during the period of incubation. This brooding habit has been referred to by Smith (1946) for six species: *Eumeces fasciatus* L., *E. laticeps* Schneider, *E. anthracinus* Baird, *E. skiltonianus* Baird and Girard, *E. s. septentrionalis* Baird, and *E. obsoletus* Baird and Girard.

The species *E. obsoletus* is the subject of the present report. Taylor (1936) suggested that the female of this form broods its eggs since it has been collected close to its nest. My observations of the female recorded with 16 mm. motion pictures will describe such activities as the daily turning and cleaning of the eggs, moving eggs to shelter when they are exposed to view, active assistance in the hatching process, grooming of the young, and the behavior toward the young during the feeding period.

## Preliminary Procedure

A pair of *Eumeces obsoletus* Baird and Girard was secured from Kansas in October and were kept together in a glass vivarium which measured twelve by twenty-four inches. An inch of sphagnum moss covered the floor of the cage beneath three large pieces of birch bark. The litter was kept damp by frequent sprinkling with water. A petri dish of fresh water was kept in one corner. A glass cover prevented excessive evaporation within the aquarium. The skinks were particularly fond of meal worms but also ate bits of uncooked liver. On sunny days the lizards spent hours on the top of the bark, but at other times they remained below the bark except when food was dropped into the cage.

On April 20, considerable activity was noted as the male which was distinguished by the orange-red flush on the sides of the head followed the female about the vivarium. On April 22, the male raced after his mate, nipping at her tail. Later in the day he caught the skin of her flank in his jaws and finally grasped her by the skin of the neck. At the same time his tail slipped beneath hers as copulation took place lasting for six minutes, in the manner similar to that described by Fitch (1954) for *E. fasciatus.*

The genus *Eumeces* exhibits a remarkable series of behavioral patterns. In all the species in which behavior is described the fighting, courting, and maternal care in *Eumeces* appear to be surprisingly uniform. Attempts to delineate species differences in behavior are difficult because *Eumeces* as well as the entire autarchoglossid group of lizards is powerfully oriented in behavior in terms of olfaction. Numerous studies have been made (see bibliography in Abel, 1951) upon this group which prove quite conclusively that lizards in this group distinguish sex of intraspecific individuals at a distance. Prospective mates, rivals, and food are revealed to them by trailing in which the tongue-Jacobson's organs and olfactory structures proper are utilized.

This courting technique of the male *Eumeces* is quite similar to that of many genera, especially those possessing excellent olfactory powers. It may relate to the distinctive "male" smell or "female" smell which is known to exude from the body (Abel, *op. cit.*) of male or female, respectively. It is not unlikely that the successive bites inflicted by the male, farther and farther forward on the body of the female serve to arouse not only the latter by virtue of the tactile stimuli but the male as well by means of the olfactory stimuli elicited which serve as releasers, until finally mating can be consummated. Fitch (*op. cit.*, 49–50) appears to agree with this view as follows: "... My own observations indicate that the capacity for sex discrimination in this particular kind of lizard, and probably in others, has been underrated. For example, it has been stated that the male rushes with open mouth at the neck of any other skink that happens to be around, and he identifies it as a male if it fights back, or as a female if it does not (Noble & Bradley, 1933). On the contrary my observations indicate that sex recognition occurs almost as soon as the male is aware of

another skink's presence. The red head of the breeding male is an excellent example of a social releaser in the sense that this term was used by Tinbergen (1948:8). Like the red belly of the breeding male stickleback, it facilitates sex recognition and evokes hostile behavior on the part of other males. Courtship, mating, and fighting reactions however, seem to be evoked by the interaction of a complex of social releasers." It is probable that skinks utilize a combination of visual, olfactory and even auditory releasers as an aid to sex discrimination *at a distance*, including tactile and olfactory releasers after contact has been made.

By June 1, the female had become noticeably heavier and the male was removed. Each day thereafter the bark was very slowly lifted for a moment of observation. Nineteen eggs were counted on June 8. The lizard had pushed aside the moss beneath the bark, forming a depression in which the eggs were clustered with the body of the female encircling them. The eggs averaged (June 8) 12 mm. by 19 mm. in dimensions. Forty-one days elapsed between the observed mating and egg-laying.

## Maternal Behavior

### Part I.—Care of the Eggs

An analysis of the instinctive activity associated with the care of the eggs reveals two aspects, each distinctive and important. One relates to the efforts on the part of the parent to protect the clutch from harm from both vertebrate and invertebrate predators. The other relates to the regular turning and cleaning of the eggs and efforts to prevent their desiccation.

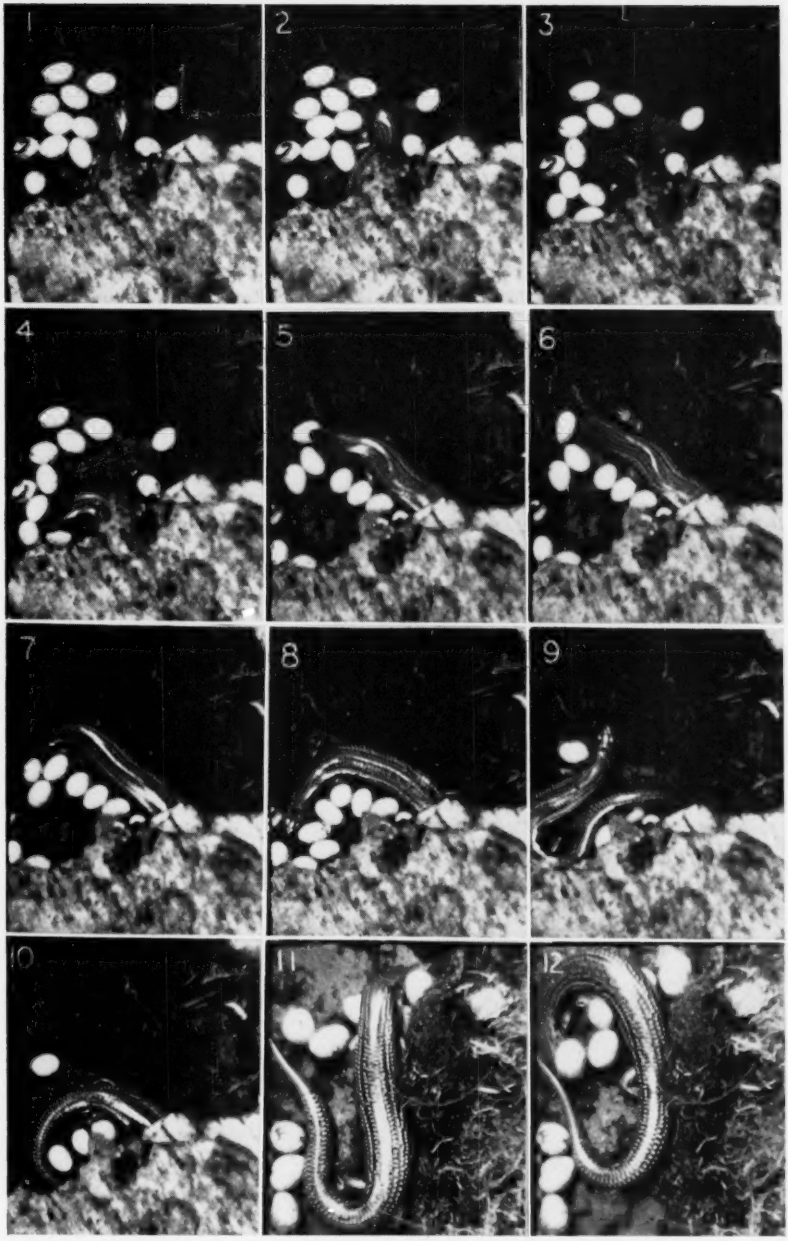
The first episode reported here pertains to protection from such environmental factors as desiccation or predators. It is illustrated with enlargements selected from a 16 mm. motion picture. It depicts the female as she strives to roll 12 of her 19 eggs back under a piece of birch bark which had been moved to expose them. This action occupied 70 seconds, during which the camera was run continuously at 16 frames per second. This was done in order to time precisely the movements of the female in this type of behavior, at least so far as the camera can be depended upon for accuracy.

In Figure 1, 51 frames after she emerged from beneath the bark, the female assumes a position preparatory to moving two of the eggs that are nearest to her left side, toward the shelter of the bark. Her technique consists in nudging with her snout each egg in turn alongside her body (Fig. 2); then with her head hooked around the last egg in line, she moves sidewise toward the cover. This action (52 frames later) rolls the eggs forward (Fig. 3). Twenty-one frames later, in Figure 4, the retrieving continues as one egg passes from view and the second is partly hidden. During the next 599 frames (37 seconds) the female has succeeded in drawing the two eggs shown to the right in Figure 4 partly under cover. In Figure 5 the lizard swings out laterally to the left to cover partly the furthermost egg of the cluster with her snout and to align them in preparation for the push that will swing them (37 frames later) into the curve of her body (Fig. 6) to the left, after 27 frames, and toward the shelter (Fig. 7).

A final spurt of sidewise pushing sends the eggs rolling to the edge of the bark (Fig. 8). In Figure 9 (243 frames later) we note that she has pushed all but four beneath the shelter. Three of these are partly hidden, but the fourth was kicked into view accidentally as she changed position. In Figure 10 (26 frames later), she has turned away from the single egg and darts under the bark without, however, moving the cluster of three any farther out of view. Some minutes later these were also rolled beneath the bark, but no further film was exposed on this episode.

The usual explanation that the female hovers about her nest to protect it from arthropod or vertebrate predators seems to be but a partial answer. It was observed that if the bark covering the nest was raised very slowly, the female was not quiescent, but was moving swiftly from egg to egg, rolling this one, upending the next, pushing another, always flicking the tongue over the egg surfaces, shifting and turning the eggs individually. She exhibited no sudden movements as though frightened by the intrusion. By approaching the vivarium slowly and silently, the female could often be seen beneath the bark, vigorously arching her neck and pushing her snout between the eggs, thus rotating them with a prying motion. It might be significant that the eggs appeared to be rolled or up-ended, rather than merely *moved*. Of course, the eggs could be rolled with less output of energy than by pushing as distinguished from rolling. Egg rotation would be required if a rhythmic shift in the position of the enclosed embryo and its membranes is necessary for its normal development, as in the case of the bird. This ac-

Figs
broodi




Figs. 1–10.—Female returns eggs to shelter of bark when exposed to view. Figs. 11 and 12.—Active brooding continues through the final day of incubation. See text for details.

tivity might mean that the female rotates its eggs for much the same reason that motivates the brooding bird. Halver (1931) turned the eggs of a non-brooding lizard, *Lacerta sardoa*, regularly during the period of incubation with the result that the vascular system of the embryos was injured. On the other hand, Fitch (1954:64) has demonstrated that the eggs of *E. fasciatus*, when deserted by the attending parent, showed a very high mortality rate.

To test the regularity with which the eggs were rolled, each was held with sterile tweezers and marked with a distinctive system of dots with a freshly sharpened soft graphite pencil (to reduce odor contamination). Each day with the momentary lifting of the bark that covered the clutch, a quick sketch of the nest was made. The results of this experiment were suggestive, in as much as the several sketches showed an ever-changing pattern of egg positions as proven by the altered arrangement of eggs and markings. The female continued to lick and turn its eggs regularly during the 29 days of incubation. Footage taken July 6, the day before hatching, showed the same maternal care that had persisted throughout the period (Figs. 11 and 12).

### Part II. Assistance Rendered by the Mother During Hatching

These notes relate to the active part assumed by the parent skink during the hatching process of the last of her brood of 19 baby lizards. This consisted in resting her head or body, or even foot, upon the shell and partly emerged body of the hatchling for several seconds at a time; or of actually rolling or rubbing the youngster. Whenever the adult touched the young one it moved spasmodically. The ultimate effect of such maternal activity caused the youngster to wriggle free of the shell. This episode was continuously filmed for a total of one minute and forty seconds, during which the mother visited the hatchling seven times.

Nine seconds elapsed while the mother rubbed and apparently applied pressure to the body of the partly hatched baby. The latter squirmed during this interval. The female then moved about the cage, smelling empty egg shells, but 83 frames later she returned to crawl over the emerging young. While still directly over it, and for 75 frames, she shifted quickly to the right. Figure 13 shows the mother smelling and nosing the empty shell beneath which lies another baby, where she remained for 61 frames. In Figure 14 the skink is shown returning to the emerging offspring again, where she rests with her snout touching it while a second youngster stops to nose it. The parent then apparently smells a second baby which lies just two centimeters to the left. A third young one pauses by the hatchling. The old one then moves about methodically prodding each shell as she comes to it.

The skink returns to rub her chin over the hatchling as the third youngster mentioned above crawls away. During the rubbing the mother's head passes from right to left, moving about an inch in the interval of 40 frames. In the next 40 frames she continues to rub her chin over the baby, passing to the left then back to the right, one half inch each way. During the ensuing five seconds she investigates empty shells, but quickly returns to cover the young one with her chest, moving slowly to the right and forward. For the next 17 frames she shifts her body backward across the youngster and during the following five seconds she moves forward very slowly while swinging her head around to nose the little one. During the next 20 frames the hatchling is brought into the hollow of her curved body, and her body is brought across and over the baby, passing to the left (40 frames). Her knee rests on the shell and the little skink's head is beneath the mother's flank. During the next 62 frames, her foot rests upon its head while she lies upon its body.

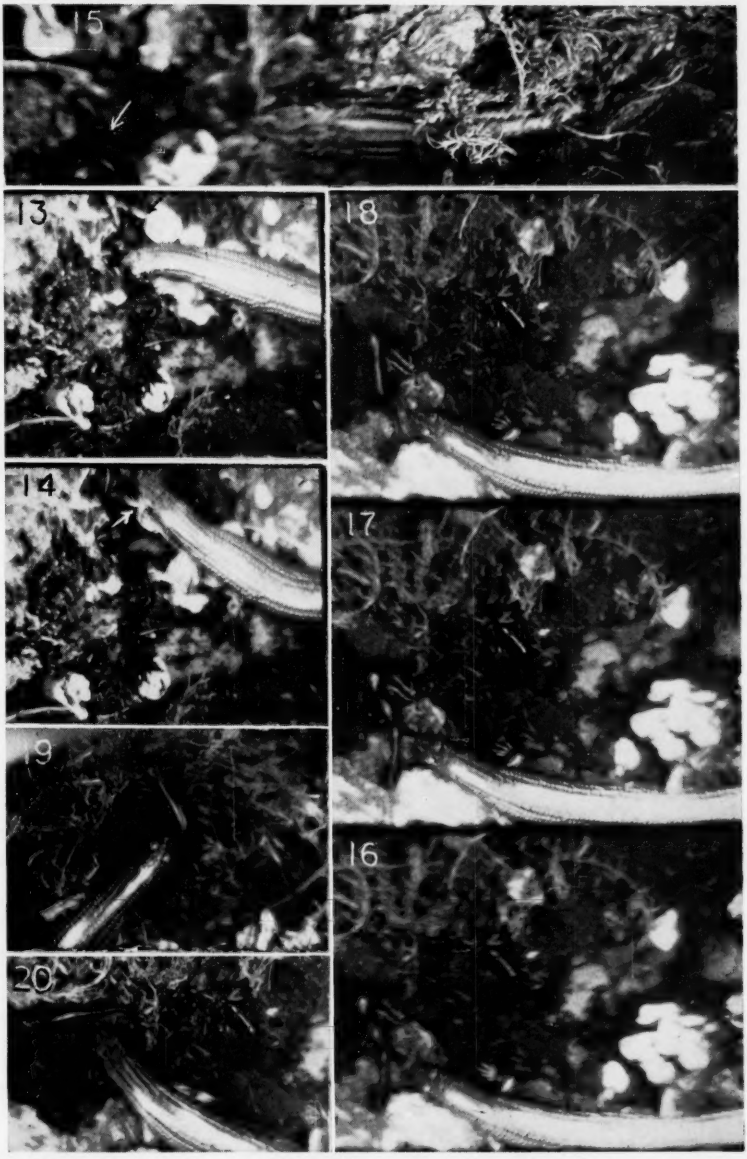
During the ensuing 20 seconds the parent prods four other egg shells and then is back for seven seconds, to rest her body upon the hatchling. For the next 66 frames she noses six empty shells, then she prods in the moss for a little over a second. At the 21st frame she has probed her snout beneath a youngster's body, raising it to the surface of the moss. During the next 200 frames she still "roots" in the moss, circling about, as if to arouse the young ones that have recently hatched.

The skink then returns to the hatchling, which has by now emerged about two inches. Within the next 86 frames the youngster has completely freed itself of the fetal membranes and squirms slowly away. Just beyond the big one's nose lies the empty shell and still farther is the twisted black body (Fig. 15) of the newly hatched offspring. The incubation period was 29 days.

### Part III. Maternal Grooming of the Young, Ten Days After Hatching

In this episode is shown, by continuous filming, the manner in which the parent re-

Figs.
emergin
parent i
days po
See text




Figs. 13, 14.—Female "assists" a tardy hatchling in hatching. Arrows indicate the egg with head emerging. Fig. 15.—The youngster has emerged (see arrow) and lies to left of its shell and head of parent is to right. Figs. 16, 17, 18.—1/16 second apart. Shows mother licking vent of youngster, 10 days post hatching. Figs. 19 and 20.—Two other juveniles receive similar maternal ministrations. See text for details.

sponds to her offspring 10 days after the date of hatching. This response does not take the form of prey-seeking but does relate to that type of parental care that can be called grooming. The female searches methodically through the litter to lick the cloacal vent of each juvenile she locates. This action may be quite perfunctory, lasting exactly one sixteenth second (one frame) or relatively long, slightly over a second in duration.

In Figure 16, the female is shown approaching the vent of a youngster. In Figure 17, one frame later, she licks it and in the next frame, Figure 18, the tiny skink moves out of range. Eighteen frames farther on, the mother approaches a second young one to lick at the vent for a period of 12 frames (Fig. 19). After 51 frames, during which the skink probes in the debris with her snout, she locates a third baby which she licks in the same manner during the ensuing 18 frames. After almost a second she returns to lick the third one again for 8 frames and after the lapse of another second she comes back to lick the third baby again; this time for 15 frames (Fig. 20).

In this scene, lasting 181 frames, the skink visited juveniles five times to lick or groom them for an average of 0.67 second each, while the average time spent in searching for youngsters in the litter consumed an average of 1½ second. The camera was run continuously during the episode as described.

### Maternal Feeding Pattern

Small mealworms and very small fragments of fresh beef liver were eaten avidly by the young skinks. Such morsels were distributed over the surface of the birch bark. During the feeding period the young ones darted about swiftly to snatch at the food. During the first sixteen days after hatching, which took place July 7, it frequently happened that as the parent reached for a morsel, a youngster gulped it from beneath the mother's snout. The latter invariably withheld her intended bite at the food, permitting the young one to eat unmolested. Even when a large meal worm or adult-size bit of liver was dropped in front of the mother, she closed her empty jaws and waited as the food was snatched by a swiftly moving skinklet who wrestled with it and struggled to swallow it before another young one could bite at it. This indulgence on the part of the parent is the more remarkable since she had been fed in this manner since the previous October and was, of course, in the habit of leaping instantly at each meal worm as it was dropped near her snout. Such behavior on the part of the mother skink toward her offspring was repeatedly observed at the daily feeding period. The parent was removed from the vivarium on the seventeenth day after date of hatching, at which time all the 19 offspring were alive and healthy.

### Discussion

Several items are worthy of mention in connection with maternal care in reptiles. With reference to egg-care, mention should be made of the facts related by Fitch (1954) for *E. fasciatus*. According to this author, if the weather becomes especially dry, the female frequently changes the nesting site to one possessing greater moisture or more shade. If eggs are already deposited, the parent digs the soil beneath them, thus increasing the humidity. The female is also known to void water from the bladder to moisten the nest cavity.

The present study of *Eumeces* as well as that of Fitch (*op. cit.*), Cagle (1940), and Breckenridge (1943), indicate that the tongue is utilized in orienting the eggs. It has been pointed out by Broman (1920), Baumann (1929), and Kahmann (1932), that in the case of snakes and autarchoglossid lizards such as skinks and lacertids, the bifid tongue is flickered along trails as the tips are repeatedly passed into the paired Jacobsen's pits in the roof of the mouth. There, osmotic particles picked up by the tongue are deposited to stimulate the accessory or vomero-nasal nerve endings.

Elaborate mutilation experiments have been devised (Noble *et al.*, 1936*a*, *b*) in efforts to disprove the findings of these earlier workers, but it remained for Wilde (1938) to confirm their studies, proving that the vomeronasal nerves and Jacobsen's pits are even more important than the olfactory nerve in trailing activities. This research was continued by Kahmann in 1939, and also by Pratt (1948) and Bellairs (1949). In the efforts of Noble and Mason (1933:1, 9) "to determine whether reptiles can recognize their own eggs," we learn that their experimental females required as long as three hours or even "the following night" to discover their eggs! Such a lapse indicates only that, driven by the maternal urge, even though deprived of the use of all distance receptors, each female none the less found by tactile searching the familiar texture and curves of its eggs.

Noble and Mason (1933:13) state that "impulses coming from Jacobsen's organ main-

tain a sustained interest in a particular object for long periods. . . but in general the interest resulting from optical stimulation is less sustained." Apparently the authors were unaware that the so-called sustained interest is dependent upon continuous stimulation and applies to any sensory modality. Among the autarchoglossids, the vomero-nasal and olfactory tracts play a major role in food-getting and social behavior (Abel, 1951:123–4; Bellairs 1949:140–3), whereas in the Iguania (iguanids and agamids) vision, not olfaction, is of chief importance (Evans, 1938; 1938*a*; 487; 1953). The studies of Fitch (1954:63) as well as my own notes on *E. obsoletus* fail to confirm the idea that an important function of the attendant female was to transfer heat from absorbed solar heat to the clutch—"chiefly at night or on dull days," as maintained by Noble and Mason (1933:16).

## Summary

This is a study of an analysis of a 16-mm. film taken during and at the close of incubation and for the ensuing two weeks.

*Care of the eggs (laid June 8).*— Continuous filming of the female while hiding 12 eggs beneath a piece of bark after being exposed to view required *70* seconds. Four eggs were left exposed at end of the episode but were ultimately retrieved. Daily sketches of positions of marked eggs in the nest proved definitely that they were rotated with great regularity throughout the period of incubation.

*Maternal care at hatching (July 7) of the last of a brood of 19 offspring.*—This consisted in resting her head, body, or foot upon the partly emerged youngster, or of actually rolling or rubbing it for several seconds at a time. With each maternal contact, the youngster wriggled farther from the shell until final emergence. In a film-exposure time of *110* seconds, the female visited the tardy hatchling *8* times for a total of 49 seconds (average 6 seconds per visit) while she probed and prodded other youngsters and egg shells a total of 61 seconds (average 10 seconds). One might well imagine the very great maternal activity which occurred during the hatching of the other 18 young ones.

*Grooming.*—Ten days after hatching, the female was photographed (3 minutes) as she licked the cloacal region of one offspring once, a second one twice, and a third one three times, with a total licking time of 55 seconds (average 9 seconds). During the intervening intervals (average 25 seconds), the mother probed for other youngsters.

## Literature Cited

Abel, E. 1951. Über das Geruchsvermögen der Eidechsen. *Österr. Zool. Zeitschr. 3:84–125.*

Asana, J. J. 1941. Further observations on the egg-laying habits of the lizard, *Calotes versicolor* (Boulenger). *Jour. Bombay Nat. Hist. Soc. 42:937–39.*

Baumann, F. 1929. Experimente über den Geruchssinn und den Beuteerwerb der Viper (*Vipera aspis* L.). *Zeitschr. vergl. Physiol. 10: 36–119.*

Bellairs, A. d'A. 1949. Observations on the snout of *Varanus*, and a comparison with that of other lizards and snakes. *Jour. Anat. 83:116–46.*

Breckenridge, W. J. 1943. The life history of the black-banded skink, *Eumeces septentrionalis septentrionalis* (Baird). *Amer. Midl. Nat. 29(3):591–606.*

Broman, J. 1920. Das Organon vomero-nasale Jacobsoni—ein Wassergeruchsorgan. *Anat. Hefte 58:143–91.*

Cagle, F. R. 1940. Eggs and natural nests of *Eumeces fasciatus*. *Amer. Midl. Nat. 23(1):227–33.*

Evans, L. T. 1938. Cuban field studies on territoriality of the lizard, *Anolis sagrei*. *Jour. Comp. Psych. 25(1):97–125.*

———. 1938*a*. Courtship behavior and sexual selection of *Anolis*. *ibid. 26(3):475–97.*

———. 1953. New facts bearing upon the behavior of the male lizard, *Anolis carolinensis*. *Anat. Rec. 117(3):606.*

Fitch, H. S. 1954. Life history and ecology of the five-lined skink, *Eumeces fasciatus*. *Univ. Kansas Mus. Nat. Hist. Publ. 8(1):1–156.*

Halver, Rudibert. 1931. Zum ersten Male in der Gefangenshaft geborene junge *Lacerta sardoa*. *Blät. Aquar. Terr. 43:250–1.*

Kahmann, Herman. 1932. Sinnesphysiologische Studien en Reptilien. I. Experimentelle Untersuchungen über das Jakobson'sche Organ der Eidechsen und Schlangen. *Zool. Jahrb. Abt. Allg. Zool. Physiol. Tiere 51:173–238.*

———. 1939. Über das Jacobsonsche Organ der Echsen. *Zeitschr. vergl. Physiol. 26:669–95.*

Noble, G. K., and H. T. Bradley. 1933. The mating behavior of lizards; its bearing on the theory of sexual selection. *Ann. New York Acad. Sci. 35:25–100.*

———, and H. J. Clausen. 1936*a*. The aggregation behavior of *Storeria dekayi* and other snakes with especial reference to the sense organs involved. *Ecol. Monog. 6:271–316.*

———, and K. F. Kumpf. 1936*b*. The function of Jacobson's organ in lizards. *Jour. Gen. Psych. 48:371–82.*

———, and E. R. Mason. 1933. Experiments on the brooding habits of the lizards *Eumeces* and *Ophisaurus*. *Amer. Mus. Nov. 619:1–29.*

Pratt, C. W. M. 1948. The morphology of the ethmoidal region of *Sphenodon* and lizards. *Proc. Zool. Soc. Lond. 118: 171–201.*

Smith, H. M. 1946. Handbook of lizards. *Comstock Publ. Co., Ithaca, N. Y.* xxi + 557 pp.

Taylor, E. H. 1936. A taxonomic study of the

cosmopolitan scincoid lizards of the genus *Eumeces* with an account of the distribution and relationships of its species. *Univ. Kansas Sci. Bull. 23:1–643.*

WILDE, W. S. 1938. The role of Jacobson's organ in the feeding reaction of the common garter snake, *Thamnophis sirtalis sirtalis* (Linn.). *Jour. Exp. Zool. 77(3):445–65.*

RESEARCH LABORATORY, JAFFREY CENTER, NEW HAMPSHIRE.

# A Study of the Sand Skink, *Neoseps reynoldsi* Stejneger*

SAM ROUNTREE TELFORD, JR.

*NEOSEPS REYNOLDSI* was briefly described by Stejneger (1910) from a specimen (in alcohol) collected by A. G. Reynolds at Fruitland Park, Lake County, Florida. Mention was made of a possible relationship to certain Old World lizards.

Prior to 1941, there were apparently only four other references to the species, other than those appearing in the editions of the *Check List of North American Amphibians and Reptiles.* Barbour (1926:55) mentioned *Neoseps* as being "a fine example of the sand swimmer." Ditmars (1936:112) commented on the discovery of the lizard, and repeated Stejneger's original description. Burt (1937:368) gave a more detailed description, and cited the localities from which the specimens in the United States National Museum were collected. Carr (1940:77) recorded information on its habitat and habits.

Smith (1946:395) gave descriptions of color and scalation, recognition characters, and the size and range of *Neoseps.* He mentioned the dearth of published information on its natural history, and the lack of data which would reveal its relationship to other genera.

Thus, until the publication of Cooper's paper (1953) on the natural history of *Neoseps* in Polk County, Florida, our knowledge of this lizard was extremely vague. Cooper developed a method of collecting *Neoseps* by digging under logs in burned-over areas of rosemary scrub. With knowledge of this technique and the aid of various companions, I have collected over sixty specimens. In all, 142 preserved specimens were examined in order to determine the extent of variation in scalation, pattern, body proportions, sexual maturity, and sexual dimorphism.

* This paper was originally presented at the annual meetings of the ASIH at Gainesville, Florida, in September 1954. Its publication has been delayed by the writer's tour of military service in Tokyo, Japan, from 1956 until the present.

## ACKNOWLEDGMENTS

I wish to express my gratitude to the following persons. Lt. Byrum W. Cooper (U.S.A.F.) was responsible for my early interest in *Neoseps.* Robert E. Hellman and Edwin H. McConkey aided both in the field and with research suggestions. Data on specimens in the collections of their respective institutions were contributed by Arthur Loveridge (Museum of Comparative Zoology), Norman Hartweg (University of Michigan), Hymen Marx (Chicago Natural History Museum), and Neil D. Richmond (Carnegie Museum). Thanks are especially due Doris M. Cochran for the loan of the excellent series of sand skinks in the United States National Museum. Horton H. Hobbs, Jr. allowed me to use the facilities of the Miller School of Biology, University of Virginia, and criticised the manuscript. Chester A. Mann of Winter Haven, Florida, also criticised the manuscript. Archie F. Carr and Coleman J. Goin of the University of Florida aided in determining locality records, as did John W. Crenshaw. Wilfred T. Neill of Ross Allen's Reptile Institute, and L. Neil Bell of Miami provided information on the occurrence of *Neoseps* in Marion County and the lower east coast area, respectively. Thomas M. Ballentine of the University of Virginia made the illustrations of skeletal parts.

Without the considerable help of Charles M. Bogert of the American Museum of Natural History, a large portion of this work would be incomplete. I wish to express my deep gratitude to Mr. Bogert for the loan of specimens, contribution of data, criticism of the manuscript, and for many helpful suggestions.

Finally, I wish to express appreciation to Mrs. Ann S. Telford of Winter Haven, Florida, for her endless patience during the preparation of the manuscript for publication.

## Methods

In each specimen, the scalation of the head was examined and the longitudinal scale rows at approximately mid-body were counted transversely around the body from the mid-ventral row back to the mid-ventral row. A slit was made in the abdomen to determine the sex of the individual and to remove the digestive tract for analysis of contents. The criteria by which sexual maturity was determined were the presence, in females, of large ova and a thickened, twisted oviduct; and in males, enlarged testes and vas deferens. Each specimen was measured with a millimeter ruler, and measurements were accurate to ±2 mm. The snout-vent length was measured from the tip of the snout to the anterior edge of the vent, and the tail length, from the anterior edge of the vent to the tip of the tail. Regenerated tails were not measured.

The following method of preservation is recommended: harden for approximately a week in 4 percent formalin, and then transfer to 75 percent ethyl or isopropyl alcohol. Specimens darken quite rapidly if left for a greater length of time in formalin.

## Habitat and Distribution

Sand skinks have been reported from high pine and rosemary scrub areas (Carr, 1940). My specimens were collected only from the latter.

Florida's scrub has been described by Kurz (1942) as the second stage of dune succession. Basically, scrub is composed of an association of palmetto (*Serenoa*) with several species of dwarfed oaks (*Quercus*) and scattered sand pine (*Pinus clausa*) on white St. Lucie Fine sand. This stage may be succeeded by any of three associations: most often, high pine (primarily longleaf pine, *Pinus palustris*, and turkey oak, *Quercus laevis*), with an accompanying change in soil from St. Lucie Fine sand to yellow Norfolk sand; a more advanced scrub stage, ranging from very thick stands of sand pine to live oak (*Quercus virginiana*) hammocks, which is usually on grayish Lakewood sand; or occasionally a transition to slash pine (*Pinus caribaea*)—palmetto flatwoods, with dark Leon sand. With the succession to pine flatwoods, the zone of transition (ecotone) is usually rather gradual. When scrub is succeeded by high pine, however, the change may be quite sudden, and one may walk along plucking turkey oak leaves with one hand from the high pine area, and sand pine leaves with the other, from the scrub.

There are apparently two types of scrub in Polk County: the typical rosemary scrub, and that hereinafter referred to as palmetto scrub. The characteristics of the two are much the same, but they are distinguished by the presence of rosemary (*Ceratiola ericoides*) in the rosemary scrub, and the complete lack of it in the palmetto scrub.

Patches of the Central Florida rosemary scrub are usually divided into two distinct zones, the central and peripheral areas. In the central area, the sand is very dry and porous, and surface moisture passes to deeper layers rapidly. Here the flora is primarily rosemary, and thinly scattered cactus (*Opuntia*) and saw palmetto (*Serenoa repens*). There are several forms of lichens (two species of *Cladonia*, locally termed "reindeer moss," and *Astraeus*) generously distributed on the ground. Apparently the only species of lizard inhabiting this area is *Sceloporus woodi*. The porosity and subsequent dryness of the soil probably render it unfit for fossorial forms such as *Neoseps* and *Rhineura*.

The peripheral area typically contains sand pine, saw palmetto, cactus, twin oak (*Quercus geminata*), myrtle oak (*Q. myrtifolia*), and scattered rosemary. Here the herpetofauna is extensive. I have recorded *Bufo quercicus, Bufo t. terrestris, Hyla femoralis, Eleutherodactylus ricordi planirostris, Rana c. capito, Rhineura floridana, Sceloporus woodi, Cnemidophorus sexlineatus, Anolis c. carolinensis, Eumeces egregius onocrepis, Eumeces inexpectatus, Ophisaurus attenuatus longicaudus, Ophisaurus compressus, Coluber constrictor priapus, Masticophis f. flagellum, Opheodrys aestivus, Elaphe g. guttata, Pituophis melanoleucus mugitus, Thamnophis s. sirtalis, Micrurus f. fulvius, Sistrurus miliarius barbouri, Crotalus adamanteus,* and *Gopherus polyphemus*. In addition, *Stilosoma e. extenuatum, Tantilla coronata wagneri,* and *Drymarchon corais couperi* should be considered usual inhabitants, although I have not yet collected them from this habitat.

In this peripheral area, where the surface of the soil is usually quite dry, moisture is present from one inch down. Under the trees and shrubs, beneath the scattered debris such as rosemary, pine, and oak twigs, fallen Spanish moss, pine needles, oak leaves, and logs, enough moisture is present to support a variety of invertebrate animals, and here *Neoseps*

is found. I suspect that the two most important factors which determine the abundance of the lizard are food supply and moisture; the ecotone between rosemary scrub and palmetto-pine flatwoods provides conditions that maintain these factors at an optimum. Much collecting time was wasted working over the dry, central areas.

EARLY PLEISTOCENE SHORELINES OF FLORIDA

Fig. 1.—Localities from which *Neoseps reynoldsi* is recorded, in correlation with the early Pleistocene physiography of Florida. 1—Lake County (Eustis and Fruitland Park). 2—Polk County (four separate scrub areas within eight miles of Winter Haven). 3—Highlands County (Lake Placid). 4—Dade County (doubtful record from Buena Vista).

*Neoseps* and *Sceloporus woodi* occur in similar places. In Putnam County, in north-central peninsular Florida, there is a large rosemary scrub; here, although conditions approximate those in the Polk County scrubs, neither *Neoseps* nor *S. woodi* is present. The absence of both species was also noted in every palmetto scrub explored. Apparently, if the plant associations of an area of scrub include rosemary, then *Neoseps* and *S. woodi* may or may not be present, dependent upon a correlation to be discussed below. If rosemary is absent, neither lizard is present. Evidently, if one lizard is present, the other is also (except possibly in high pine, for there is doubt concerning the abundance of *Neoseps* in any type of soil other than St. Lucie Fine sand). The only high pine area that I have seen, from which *Neoseps* is recorded, is the type locality at Spring Lake, Fruitland Park, in Lake County, Florida. There is scattered rosemary in the area, so it is quite possible that small tracts of scrub were scattered through the high pine prior to the extensive destruction of natural areas by man.

The association of *Ceratiola, S. woodi,* and *Neoseps* appears to be limited to the central scrub areas—*S. woodi* and *Ceratiola,* for instance, are found on Marco Island, Lee County, Florida, but there are no records of *Neoseps* from the southwest Florida region.

*Neoseps* has been recorded from Alachua, Dade, Lake, Polk, and Highlands counties. I have personally examined specimens from the latter four. The specimen said to have been collected in Alachua County has not been located. Carr (1940:77) recorded the species from Alachua County on the basis of a museum record. I questioned Dr. Carr about this record, and was told that the locality data were in error. There are no areas of rosemary scrub in Alachua County, and in view of the possibility of doubt concerning the existence of *Neoseps* in high pine, I believe that Alachua County lies outside its range. Wilfred T. Neill has no records of *Neoseps* from Marion County, immediately south of Alachua, although there are extensive tracts of rosemary scrub in Ocala National Forest and the Big Scrub. Therefore, Lake County must be considered the northern limit of the range.

The Dade County record may be incorrect. This will be discussed in more detail later.

The range of *Neoseps* is restricted to Lake, Polk, and Highlands counties, which occupy the large central island of the second interglacial period, where it is evidently confined to marginal areas of rosemary scrub.

## Influence of Pleistocene Physiography on Present Distribution

Cooke (1939) has shown that the present scrub areas in Florida are remnants of Pleistocene dunes and shore lines. A study of the possible influence of the Pleistocene insular land masses on the present range of *Neoseps* has led to the formulation of a hypothesis regarding a segment of the evolutionary history of the species.

During the first interglacial period, there was a considerably greater rise in sea level than during the succeeding interglacial periods. Almost all of Florida, and most of the Atlantic Coastal Plain were under water during this first interglacial period. The small areas of land, in what is now peninsular Florida, that remained above water are delineated by the presence of Sunderland terrace (Cooke, *op. cit.*). The old dunes marking this shore

line are present in north Florida, well out of the range of *Neoseps*, and in northern Polk County. During the second glacial period, there was a marked lowering of sea level, and probably most of the Atlantic Coastal Plain was inhabited by forms of life that could tolerate a low, damp habitat. I propose that a scincoid lizard, possibly similar to *Eumeces egregius*, was widespread over this post-Sunderland coastal plain. With the advent of the second interglacial period, small populations of this lizard were isolated on the large central Florida island, delineated by the Wicomico terrace. This period of isolation lasted approximately 300,000 years—which was possibly sufficient time for the evolution of a skink especially adapted for fossorial existence. The range of *Neoseps*, with the exception of the dubious Dade County record, lies entirely within the area of this large Pleistocene island. McConkey (1954) has presented a similar theory for the origin of the scrub and dune-dwelling *Ophisaurus compressus*. During the third glacial period, the sea level remained high, and the large central island remained almost completely separated from the mainland. This provided another 100,000 years of partial isolation from the continental population for the skink population of the island. During the third interglacial period, little rise in sea level occurred, and the island was completely re-united with the mainland, in which condition it has remained to the present.

There are two explanations of the Dade County record (other than inaccurate locality data). One might postulate that *Neoseps* spread down the east coast along the sand dunes to Dade County. If this had occurred, then scattered colonies of *Neoseps* might be expected at intervals along the east coast, since what appears to be suitable habitats are present. There are no records from coastal counties. Mr. L. Neil Bell told me that the presence of *Neoseps* along the lower east coast seems indicated from the reports of farmers. These, however, could be based upon *Eumeces egregius* or even *Rhineura floridana*, as both occur in the lower east coast area as far south as Miami. The other explanation is that the lizard was introduced to the Downey estate near Buena Vista, from which locality M. K. Brady collected two specimens, during transplantation of shrubbery.

It is quite possible that following the reunion of the central island to the mainland during the third interglacial period, the ancestral stock once again migrated to the island and became what is today known as *Eumeces egregius onocrepis*, a semi-fossorial inhabitant of the central scrub and high pine areas and the coastal dunes. There is some anatomical similarity between *Neoseps* and *E. e. onocrepis* to support this idea. Both lizards have limbs that are greatly reduced in size, although there has been no loss of digits in *onocrepis*. There are usually four supraoculars in the genus *Eumeces*, but *onocrepis*, like *Neoseps*, possesses three supraoculars. Both species have a small number of scale rows around mid-body, 18 to 22 in *onocrepis* and 14 to 17 in *Neoseps*. The ear opening is partly closed in *onocrepis* and absent in *Neoseps*. *Neoseps* possesses only one temporal, and this condition is paralleled in *onocrepis* by the loss of the primary temporal, leaving only the secondary present. In addition, both species are of small size, have similar habits, occupy similar habitats, and have similar life histories.

Probably *Desmognathus carri*, *Rhineura floridana*, and *Stilosoma e. extenuatum* are, along with *Neoseps* and *Ophisaurus compressus*, relict forms which were isolated on the central Florida island during the second interglacial period.

### Reduction of the Digits

The tendency of the Scincidae towards reduction and elimination of the digits is well known. In view of the unique position of *Neoseps* in the North American herpetofauna, a description of the skeletal remnants of the limbs is presented.

When viewed either in a live or preserved state, the modifications that have occurred to both pectoral and pelvic limbs are probably the most outstanding characteristic of this lizard. The hind limbs with but two digits are approximately five times the length of the fore limbs, which have but a single digit. One is immediately drawn to the conclusion that the animal relies little upon the use of such degenerate appendages as the pectoral limbs. Except for their functions during the act of copulation, as discussed in the section dealing with breeding habits, the pectoral limbs appear to be practically useless.

With the aid of two cleared specimens from the collections of the American Museum of Natural History, the writer has made a study of the skeletal anatomy. In the pelvic limb, the first, fourth, and fifth digits have been lost. The second digit has been reduced to three phalanges, and the distal phalanx is minute. The third digit is composed of three

large phalanges and a smaller fourth one. There are two tarsals, the intermedium, distal to the tibia, and the fibulare, distal to the fibula. Due to the peculiar trailing position in which the limbs are held, the thin, straight fibula is dorsal to the thicker, strongly curved tibia. The femur is long and straight.

Within the pectoral limb, only the third digit remains. This digit is represented by two phalanges. There are three metacarpals, probably the second, third, and fourth, and two carpals. The latter are represented by the ulnare, distal to the ulna, and the radiale, distal to the radius. The straight, thick ulna is dorsal to the thinner, slightly curved radius.

The unusual position in which both limbs are normally held is probably an adaptation for streamlining the body, thus adding to the creature's ability to "swim" through the sand.

## Habits

*Neoseps* probably rarely burrows more than a few inches below the surface. The specimens recorded by Carr (1940:77—received from Van Hyning) as being collected from a depth of two feet, were almost certainly accidentally deposited there by the activities of the digging workmen. The soil of the scrub, while loose for about three inches at the surface, soon becomes tightly packed, and it would be quite difficult for the lizards to penetrate it successfully. Specimens under observation for several weeks were given about ten inches of sand in which to burrow, but never were any observed more than three inches deep. I collected one specimen at a depth of four inches; this was a female that engaged in mating three days after capture. Cooper (1953) mentions specimens from a greater depth. These, however, were collected by digging beneath logs with a shovel, and likely were dislodged from a sub-surface position. With the exception of two specimens, all the *Neoseps* collected by me were within one to three inches of the surface. These two exceptions were above ground; one of these, collected at 1:30 PM on March 5, 1953, was lying in a partly coiled position beneath a log that was lightly resting upon the ground. The day was overcast, windy, and cool, and the ground was rather dry. The other specimen, collected on April 3, 1953, was on the surface among fallen leaves in the shade of a low bush. This was in the morning on a clear, hot day. Cooper (*op. cit.*) mentions a specimen found on the surface beneath a log. Possibly the only time that sand skinks burrow to depths more than three or four inches is in the periods of drought in the summer months, and during very cold weather. It might be added that comparatively few *Neoseps* are caught during these periods, and then usually beneath logs where the ground remains comparatively moist throughout the year. Judged from the number of tracks observed when collecting in the morning, it is probable that *Neoseps* prowls above ground during the evening and early morning hours. Mr. Charles M. Bogert showed the writer a photograph of *Neoseps* tracks in sand, which makes identification of the tracks frequently seen in the scrub virtually certain.

Upon being uncovered, *Neoseps* moves with a rapid swimming motion to cover itself with sand. This act of "swimming" through the sand is produced by lateral undulations of the body. Cooper (*op. cit.*) believes that the lizard moves straight down when disturbed. This seems doubtful because of the hard-packed soil existing a few inches down, which would hinder its escape, and because of this I believe that *Neoseps* burrows in a lateral direction from its previous position when it is alarmed. It is believed that many specimens have escaped because of this trait, as the collector usually attempts to dig deeper in the spot where the lizard disappeared.

One specimen, upon being unearthed and grasped, futilely worked its jaws in an attempt to bite, much as do the larger members of the Scincidae. This act has also been frequently noted in the red-tailed skink, *Eumeces egregius onocrepis*.

*Eumeces e. onocrepis* is often found among pine bark chips, along the sides of logs and at the base of trees and stumps, as well as buried in the sand, but *Neoseps* is always in sand. This is no doubt due to the differences in structure of the lizards. The red-tailed skink makes great use of its fairly well developed legs, and may move rapidly under almost any conditions of surrounding medium, but the sand skinks are almost totally dependent upon their swimming motion for movement, and this is effective only in loose sand. This provides another basis for doubting their abundance in the tightly packed Norfolk sand of the high pine areas.

Red-tailed skinks and sand skinks are often collected within inches of each other, and beneath the same logs. They probably co-exist in complete harmony, for neither species is large enough to prey upon the other. Although I have frequently observed signs of

strife among the male members of each species, I have never seen any indication of conflict between the species.

One of my specimens was in captivity from December 31, 1952, to July 28, 1953. For over a month, this individual was kept in the collecting jar along with two *Eumeces egregius onocrepis*, and apparently suffered no harm. During this period, it ate whenever food was offered.

Only two instances of predation upon *Neoseps* have been observed. One of these, in which a large *Eumeces inexpectatus* swallowed a small *Neoseps* in the collecting container, has already been reported by Cooper (*op. cit.*). The other case is the removal of a *Neoseps* from the stomach of a four-foot *Masticophis f. flagellum* by Mr. C. M. Bogert in Highlands County, Florida, on May 29, 1944. However, *Neoseps* is frequently found bearing heavy infestations of bright orange mites, similar to those so abundant on *Sceloporus woodi*.

It is not difficult to keep *Neoseps* in captivity. It is hardy, requires little space, and is easily provided with food. I have had as many as ten individuals under observation at one time. These were kept in a terrarium made by filling a five gallon water bottle with about ten inches of sand from the scrub. This provided the lizards with plenty of room for burrowing or for roaming about on the surface.

Sand skinks apparently thrive on a diet of termites. The terrarium was kept stocked at all times with termites and as long as the sand was not allowed to dry out, the lizards appeared to thrive. Probably, other small, soft-bodied insects would be just as suitable for food. Feeding has been observed both above and beneath the surface, but the latter method was most frequently used. The results of stomach analyses presented by Cooper (*op. cit.*) are the only published information on *Neoseps* food habits.

I never observed any of my sand skinks drinking water, either from a container, or from the surrounding surfaces; the animals probably obtain all the necessary moisture from their prey.

In captivity, *Neoseps* remains beneath the surface most of the time, roaming about above the surface occasionally in the afternoon. Probably, the sand skinks are active in the cool of the early morning and evening. No activity has been observed at night in the wild, though captives occasionally prowl at night.

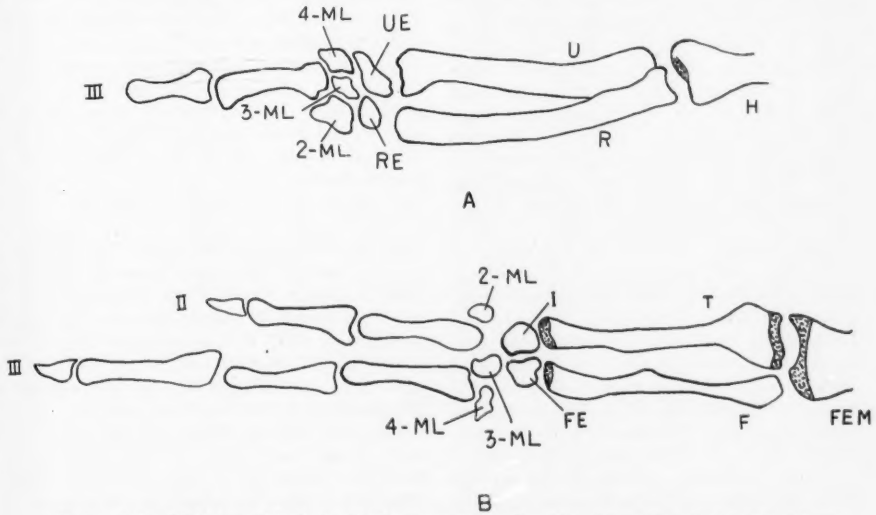



Figure 2 A.—Right anterior limb. H—humerus, R—radius, U—ulna, RE—radiale, UE—ulnare, 2-ML—second metacarpal, 3-ML—third metacarpal, 4-ML—fourth metacarpal, III—third digit.
2 B.—Right posterior limb. FEM—femur, T—tibia, F—fibula, I—intermedium, FE—fibulare, 2-ML—second metatarsal, 3-ML—third metatarsal, 4-ML—fourth metatarsal, II—second digit, III—third digit.

In captivity, *Neoseps* often lies just beneath the surface of the sand, with the head barely protruding. At the least disturbance, the head is quickly withdrawn and the lizard moves away. They tolerate very little movement in their presence without becoming alarmed.

When prowling above ground, the sand skinks constantly extend their tongues in the characteristic fashion of the Scincidae.

### Breeding Habits

The time of greatest availability of *Neoseps* lies between the first of March and the first of May. This period of abundance appears to be in direct correlation with the breeding season. During other times of the year, it is difficult to collect the lizards. After the breeding period, the females apparently seek secluded places for egg-laying and incubation, for only rarely is one discovered during the summer. Males, on the other hand, are still comparatively easy to obtain, although a great deal more labor is required to collect them than during the breeding season.

A large female collected in the Lake Thomas-Lake Sears scrub, near Winter Haven, on April 13, 1953, was marked by removal of the left forefoot, and placed in the terrarium with nine other *Neoseps*. At 3:59 PM, on April 16th, this female and a male collected from the same locality on March 6, 1953, were observed preparing to copulate. The male had grasped the female on the right side near the fore limb with his mouth, and had curved his body around hers. About two-thirds of his body was wrapped one and one-half times around the posterior part of her body. The small left foreleg of the male was rhythmically stroking the side of the female. This stroking continued for about a minute. Copulation began at 4:00 PM. The male had his body turned sideways, and his hindlegs were tightly locked about the body of the female at the region of the cloaca. During copulation, there was little movement on the part of either lizard, and the male released his hold with his mouth on the female. Occasionally, however, the male would gently move his tail from side to side. The hemipenes were never wholly visible. At 4:07, the female pulled away from the male, and slowly crawled beneath the surface. The male lay motionless for a moment, making a chewing motion with his jaws, and then quickly burrowed after the female. No further activity was observed on the surface of the terrarium, and observation was terminated at 4:15. All activity had taken place on the surface of the sand. The temperature at the time was approximately 78 degrees Fahrenheit, and some sunlight was shining on the sand.

The sand skink observed in copulation on April 16, 1953, deposited two eggs on June 10, 1953. Thus, a period of 55 days intervened between copulation and oviposition. The female was found coiled around the eggs at about 6:45 PM. The eggs were at the bottom of the glass container, under approximately two inches of sand. They were grayish white and measured 13 mm. in length by 5 mm. in width, and 12 mm. in length by 5 mm. in width. The slightly longer egg was removed to a separate container filled with damp sand, and the smaller one was left with the female. The shells of the eggs were smooth, and but for the exceptional length, the eggs resembled those of *Lygosoma laterale*.

Close observation of the eggs was continued for the next few days. During this period, the female constantly brooded the egg remaining with her. On June 15th, measurements were again taken, and the eggs were 15 mm. by 7 mm., and 12.5 mm. by 6 mm., respectively. The egg that had been left with the female was placed in the same container with the other, at a distance from the female. The shell color had darkened to light brown.

One egg was found desiccated on June 28th, and a large hole was seen in the shell of the other, July 3rd. When the egg was opened, the embryo was found to be large and well-developed, though scalation had not yet begun to appear; the eyes were quite large, and the brain well-formed. Probably the eggs would have hatched within two weeks had they been left with the female and received proper care.

Of 59 female *Neoseps* examined, only one contained oviducal eggs. These were two in number, without shells, and approximately 7 mm. in length. Cooper (*op. cit.*) records a specimen from Polk County with two oviducal eggs.

On July 27, 1953, I collected a hatchling sand skink in the Lake Thomas scrub. The afternoon (3:30 to 5:30 PM) was hot and humid; the soil was dry at the surface, but damp immediately beneath. The hatchling was about one-half inch deep in sand, beneath some fallen Spanish moss. Upon being uncovered, it moved considerably more slowly than did any of the four adults collected that day.

The specimen is obviously very young; there is a small quantity of yolk remaining in

the gut, beneath the partly-closed umbilicus. A generous estimate would place the hatchling not before the 25th of July. The snout-vent length and tail length, taken immediately before preservation, are 24 mm. and 34.5 mm., respectively.

A description of the hatchling from life follows: The dorsal surface of the body and tail is a metallic pinkish tan (almost flesh-colored.) The ventral surface of the body is grayish white, deepening to darker gray on the tail. The venter is so transparent that the internal organs are plainly visible, and in fact, these give a reddish tint to the abdomen. A wide black lateral line extends from the tip of the tail to the snout. This lateral line fades slowly to gray at the level of the anterior pair of limbs, then darkens to deep black along the supralabials. A dark spot is centered posterior to the eyes on the top of the head. The dorsal surface of the hind limbs is light gray, flecked with black; the ventral surface is light gray.

## Size and Sexual Maturity

In the course of this study, 135 specimens were measured. Only 102 of these, however, have the date of collection included with the collecting data. Fig. 3 presents the correlation of snout-vent length and sexual maturity with the months in which the specimens were collected.

The only hatchling *Neoseps* obtained measured 24 mm. snout-vent length before preservation. This hatchling was collected in July. It is assumed, on the basis of the data presented above, that individuals reach sexual maturity during their first year, as they approach a snout-vent length of 45 mm. Lizards with snout-vent lengths greater than 57 mm. are abundant during February and March, but evidently die shortly thereafter, without entering upon another breeding season. Many of these large adults show signs of senility—a darkening of the ground color, loss of weight, shriveling of gonads and ducts, and a decrease in speed of movement and activity. It is probable that the bulk of the active breeding population lies between 45 mm. and 57 mm. in snout-vent length, and are in their second year. The normal life span is probably about three years.

The maximum size reached by this species apparently is 65 mm. in snout-vent length. In the series of 135 specimens measured, the largest female was 65 mm., and the three largest males were 63 mm. in snout-vent length.

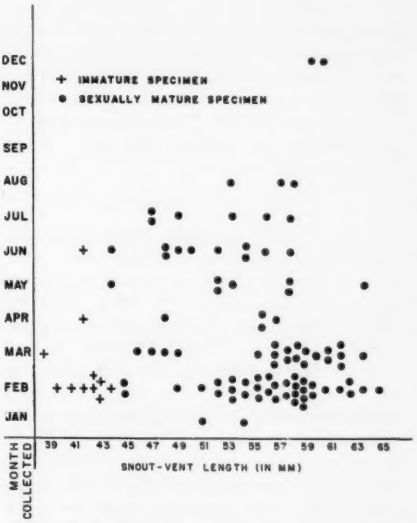



Fig. 3.—Snout-vent lengths plotted against month of collection for 102 specimens of *Neoseps*.

Only 31 percent (42) of the specimens possessed perfect tails showing no apparent regeneration. The ratio of tail length to total length was determined for 16 females and 26 males. The tail comprises 47 to 53 percent of the total length for females, with a mean of 49.6 percent. The tail constitutes 47 to 54 percent of the total length for males, with a mean of 50.5 percent. There is, then, very little sexual dimorphism in body proportions of *Neoseps*.

## Variation

During the examination of specimens, the characters considered were the number of scale rows at mid-body, the number of supralabials and infralabials, and any aberration in head scalation. Little variation was found, and no sharp deviation from the typical head scalation. Some specimens (particularly the Dade and Highlands counties specimens) showed a slight narrowing of the internasals, and others occasionally showed an elongation of the loreal or reduction in the size of the suboculars.

The number of scale rows at mid-body was determined for 142 specimens: 79 males, 59

females, and 4 individuals of undetermined sex. There were 14 scale rows present in 1 female; 15 scale rows in 1 male and 3 females; 16 scale rows in 78 males, 51 females, and 4 specimens of undetermined sex; and 17 scale rows present in 4 females. The number of supralabials and infralabials was determined for 140 specimens. Supralabials numbered 6–5 in 1 specimen, 5–5 in 137 specimens, and 5–4 in 2 specimens. Infralabials numbered 4–4 in 138 specimens, and 3–4 in 2 specimens.

### Pattern Variation

There is little variation in color pattern. The ground color may vary from dirty white to deep tan, dependent upon many conditions such as weather, season, age, and locality, but there is little noticeable difference among preserved specimens. Some individuals may exhibit prominent spotting, with a dark spot on each scale, including the venter, whereas others may show a much reduced spotting. The lateral line is occasionally reduced or non-existent. It consists of a dark line on the first three scale rows (counted from the ventrolateral keel), and extending from the posterior-most supralabial, usually to the tip of the tail. It is present on the first, second, and third scale rows in about 78 percent of the specimens examined. Only 5 percent show no trace of the lateral line; 17 percent exhibit various stages of reduction of the line, and most of them possess at least a line of dark spots along the third scale row. Immature specimens and young adults from 39 mm. to 50 mm. almost invariably show a prominent line. This is not restricted to younger lizards, as 15 of 16 large adults, from 61 mm. to 65 mm., show a distinct line on the first three scale rows. There is no appreciable sexual dimorphism associated with pattern variability.

### Summary

The range of *Neoseps reynoldsi* Stejneger is restricted to marginal areas of rosemary scrub within Lake, Polk, and Highlands counties in central Florida. These areas occupy the large central Florida island of the second interglacial period. It is postulated that the scincoid stock from which *Neoseps* is derived populated the coastal plain during the second glacial period, and that small populations of this lizard were isolated on the large central island with the advent of the second interglacial period. This isolation resulted in the evolution of a skink especially adapted for fossorial existence. In the pelvic limb, the first, fourth, and fifth digits have been lost, the second digit reduced to three phalanges, and the third digit reduced to four phalanges. In the pectoral limb, the first, second, fourth, and fifth digits have been lost, and the third digit reduced to two phalanges.

*Neoseps* is usually collected from the loosely packed sand at a depth of two to four inches, or from beneath logs during periods of drought or extreme cold. Predators of *Neoseps* include *Eumeces inexpectatus* and *Masticophis f. flagellum*. *Neoseps* eats termites readily in captivity, and feeds both above and beneath the surface of the sand. *Neoseps* apparently breeds between the first of March and the first of May. Prior to copulation, the male grasps the female with his mouth, and during the act rythmically strokes her side with his foreleg. Duration of the one act of copulation observed was seven minutes, and a period of 55 days elapsed between copulation and oviposition. The two eggs measured averaged 12.5 mm. in length and 5 mm. in width. Two eggs were present in each of the three instances in which a gravid female was examined. The single hatchling *Neoseps* examined measured 24 mm. snout-vent length, and 34.5 mm. tail length. *Neoseps* apparently reaches sexual maturity during the first year following hatching, as it approaches 45 mm. snout-vent length. Most of the individuals in the active breeding population are between 45 mm. and 57 mm. in snout-vent length, and are in their second year. The normal life span is probably about three years. The largest female examined measured 65 mm. snout-vent length, and the largest males were 63 mm. snout-vent length. In females, the tail comprises 47 to 53 percent of the total length, with a mean of 49.6 percent, and in males, 47 to 54 percent of the total length, with a mean of 50.5 percent. The number of scale rows at mid-body varies from 14 to 17, the usual number being 16 for both sexes. There is no appreciable sexual dimorphism associated with size, scalation, or pattern variability.

### Literature Cited

Barbour, T. 1926. Reptiles and amphibians; their habits and adaptations. *Houghton Mifflin Co., Boston and New York. xx + 129 pp.*

Burt, C. E. 1937. The lizards of the southeastern United States. *Trans. Kans. Acad. Sci. 40: 349–366.*

Carr, A. F. 1940. A contribution to the herpetology of Florida. *Univ. Fla. Biol. Sci. Series 3(1): 1–118.*

Cooke, C. W. 1939. Scenery of Florida interpreted by a geologist. *Bull. Fla. Geol. Survey 17: 1–118, figs. 1–58.*

Cooper, B. W. 1953. Notes on the life history

of the lizard, *Neoseps reynoldsi* Stejneger. *Quart. Jour. Fla. Acad. Sci. 16(4): 235–238.*

DITMARS, R. L. 1936. The reptiles of North America. *Doubleday, Doran & Co. Inc., Garden City, N. Y. xvi + 476 pp.*

KURZ, H. 1942. Florida dunes and scrub. *Bull. Fla. Geol. Survey 23: 1–124.*

MCCONKEY, E. H. 1954. A systematic study of the North American lizards of the genus *Ophisaurus. Amer. Midl. Nat. 51(1): 133–171.*

SMITH, H. M. 1946. Handbook of lizards. *Comstock Publ. Co., Ithaca, N. Y. xxi + 557 pp.*

STEJNEGER, L. 1910. A new genus and species of lizard from Florida. *Proc. U. S. Nat. Mus. 39: 33–35, figs. 1–6.*

U S A C R A P A C, APO 613, SAN FRANCISCO, CALIFORNIA (ARMED FORCES). FORMERLY 1720 LAKESHIPP DRIVE, WINTER HAVEN, FLORIDA.

# Distribution of the American Cyprinid Fish *Notropis anogenus*

REEVE M. BAILEY

THE recent receipt of Iowa specimens of the pugnose shiner, *Notropis anogenus* Forbes, has stimulated a canvass of museum holdings of the species and led to assembly of the distributional data. It is evident that *Notropis anogenus* is one of the rarest cyprinids in northern United States and southern Canada; largely for this reason little is known about it. Recent collecting has failed to take *N. anogenus* in some areas where it occurred in the past, for example in Illinois (Haas, 1943:162) and Ohio (Trautman, 1957:391–92). Such areas appear to have suffered radical change as a result of human land and water use, notably in increased turbidity and reduction of aquatic vegetation. *Notropis anogenus,* though spotty in occurrence and infrequently common, nevertheless has a rather wide distribution and is a characteristic inhabitant of clear, well-vegetated waters in some glacial lake areas of Michigan, Minnesota, and Wisconsin. The distribution of the species as here determined (Fig. 1) agrees quite well with Trautman's (1957:392) map.

*Notropis anogenus* is a moderately compressed, small species attaining a maximum standard length of at least 48 mm. Perhaps its most distinctive feature is the small, strongly oblique, terminal mouth. The body scales are large and rounded behind, those of the trunk are not notably deepened, and the nape, breast, and belly are wholly invested. The lateral-line scales number 34 to 37, the body circumference scales 22 to 24, and the caudal peduncle scales 12. The lateral line and infraorbital canals are complete. The pharyngeal teeth constantly number 4–4; the cutting edges are finely serrate and there are well-developed terminal hooks and grinding surfaces. The dorsal rays are usually 8 (rarely 9), anal rays 8 (occasionally 7), pectoral rays 11 to 13, pelvic rays 7 or 8, usually 8. There is a broad, lateral dark stripe, marked with concentrated spots of darker pigment around the lateral-line pores; the stripe is nearly separated from a small, wedge-shaped dark spot at the caudal base. Anteriorly the stripe passes through the eye, crosses the preorbital area and the lateral part of the upper lip, and covers the lower lip and chin; it does not invade the mesial part of the upper lip, which is usually little if any darker than the front and top of the snout. These are about equally pigmented. There is a narrow, inconspicuous postdorsal streak, but the postanal dark streak, if present, is faint. The dorsal and dorsolateral scales are broadly and densely margined with melanophores, and there is a lighter stripe above the midlateral dark stripe. Below the lateral-line row there are only a few irregularly distributed melanophores. The periproct is light. Unlike most species of *Notropis* the peritoneum is dark.

Among its sympatric congeners, *Notropis anogenus* is most apt to be confused with the blackchin shiner, *Notropis heterodon.* It differs sharply from that species, however, in having a single row of pharyngeal teeth, a very small mouth (not exceeding the anterior nostril) that is more oblique, in the obsolescent postanal streak, and in having a dark peritoneum. Because the mouth simulates that of the pugnose minnow, *Opsopoeodus emiliae,* in size and shape, *N. anogenus* is more likely to be misidentified with that form than with other species of *Notropis.* That the resemblance is due to convergent development, however, seems obvious in view of the many and impressive differences between these species (Table I). *Opsopoeodus emiliae* and *No-*

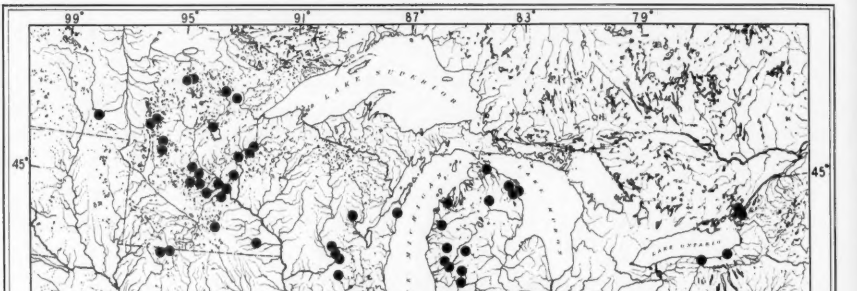



Fig. 1.—Northern United States and southern Canada showing the distribution by record stations of the pugnose shiner, *Notropis anogenus* Forbes. (Map prepared by Mrs. Elizabeth M. Anthony)

*tropis anogenus* are sympatric in some areas, for example in Lake St. Clair.

It is uncertain which among the many species of *Notropis* are most intimately related to *Notropis anogenus*. It may be noted, however, that *Notropis topeka* Gilbert shares many structural characters and bears strong resemblance. These species now appear to be allopatric although they were probably originally sympatric in north-central Iowa and southern Minnesota. Restriction in range through soil pollution of waters in the area may now prevent contact. Both seem to prefer clear or moderately clear water, but the Topeka shiner is much more tolerant of turbidity and is still common locally from southern Minnesota and eastern South Dakota to eastern Kansas and northern Missouri in an area where such tolerance is essential to survival. Both species are small and moderately robust, their scales are alike in shape and distribution and differ little in size, the lateral line is complete, the color patterns are similar, the mouth in both is terminal and oblique, and the dental count is 4–4. Among the more obvious differences are, for *topeka*, the larger and less strongly oblique mouth, the lower usual anal ray count (7), the light peritoneum, and the developed postanal dark streak. Breeding males of *Notropis topeka* have coarse and sharp nuptial tubercles on the head and much bright red or orange on the fins and lower side. I have not seen males of *N. anogenus* in breeding condition but the excellent color painting published by Greeley and Bishop (1932:pl. 4) shows only golden and yellowish colors; no nuptial tubercles are shown. Other species that are sharply distinguished from *N. anogenus* but are perhaps related to it include *Notropis ortenburgeri* and *N. bifrenatus*.

*Notropis anogenus* was described by Forbes (1885:138–39) from a series of 24 specimens collected in the Fox River, at McHenry, McHenry County, in the lake district of northeastern Illinois. No holotype was designated. The eight specimens still in the collection of the Illinois State Natural History Survey were kindly made available for study by Dr. Philip W. Smith. These are not in a good state of preservation, most having become desiccated at some time in the past, but they are clearly identifiable. Two species are represented. Six specimens, including the largest, are *Notropis anogenus* (*auct.*). It is clear from Forbes' excellent description that individuals of this form were utilized in drafting the original account. In order to preserve customary nomenclature I designate as lectotype of *Notropis anogenus* Forbes one of the original syntypes, an adult 43 mm. in standard length. The lectotype conforms to the characterization of the species given above and in

Table I. The complete lateral line has 36 scales; there are 23 body-circumference scales and 12 scale rows around the caudal peduncle. The fin ray counts are: dorsal 8, anal 8, pectoral 12–13, pelvic 8–8. The following measurements are expressed as percentages of the standard length: body depth 21.6; head length 23.5; head width 12.6; snout length 6.0; upper jaw length 4.7; lower jaw length 7.7; orbit length 8.1; predorsal length 49.5; dorsal origin to caudal base 50.9; depressed dorsal fin 23.7; pectoral fin length 14.4. The border of the upper jaw forms an angle of about 63° with the body axis. The five other syntypes that are identified with *N. anogenus* range from 29 to 34 mm. in standard length. Two of the original series, INHS, 26 and 29 mm. long, are identified as *Notropis heterodon*. Each has two rows of pharyngeal teeth (1, 4–4, 1), a large mouth that is moderately oblique and extends to below the posterior nostril, a dark postanal streak, scales on the breast, and a light peritoneum.

In its over-all pattern the distribution of *Notropis anogenus* (Fig. 1) is somewhat like that of *Hybognathus hankinsoni* (Bailey, 1954), though that species has a more extensive range, especially in the west. *Notropis anogenus* apparently had a glacial refugium in the upper Mississippi basin. From this source it has invaded the Red River drainage by way of the Lake Agassiz outlet; the Lake Superior basin (one record in the St. Louis River system of Minnesota) probably by recent water connection over the narrow, swampy area separating the St. Louis River from the upper Mississippi River; the Lake Michigan basin, probably by both the Fox and Chicago glacial outlets (Greene, 1935); and the lower Great Lakes as far as the head of the St. Lawrence River, presumably by the Maumee outlet. There is a single verified locality in the Missouri basin (Lake Okoboji, Iowa) and only one in the Ohio basin (Blue Lake, Indiana).

In the list of specimens abbreviations refer to the following collections: CNHM, Chicago Natural History Museum; CU, Cornell University; INHS, Illinois Natural History Survey; OSM, Ohio State Museum; ROMZ, Royal Ontario Museum of Zoology; UM, University of Minnesota; UMMZ, University of Michigan Museum of Zoology; USNM, United States National Museum.

I am indebted to the responsible officials who have loaned the specimens under their care. All specimens listed from the above museums have been re-examined by me. On the map I have plotted additional Minnesota records from survey collections supplied by Dr. John B. Moyle, Minnesota Department of Conservation. These identifications were made by REJ (Dr. Raymond E. Johnson), JBM (Moyle), or THC (Thomas H. Copeland). Literature reports not verified by specimen examination are omitted with the exceptions noted in the following list. Because this species is becoming rare in areas where it was formerly common, collection dates and collectors' names are recorded for most lots, except that these are omitted for Michigan, Minnesota, and Wisconsin where the species is most common.

TABLE I

COMPARISON OF *Opsopoeodus emiliae* AND *Notropis anogenus*, TWO SUPERFICIALLY SIMILAR CYPRINIDS

| Character | *O. emiliae* | *N. anogenus* |
|---|---|---|
| Teeth | 5—5 | 4—4 |
| Principal dorsal rays | Usually 9 | Usually 8 |
| Lips | Thick, the upper expanded medially and terminal | Thin, the upper not expanded medially and not exceeding skin of snout |
| Dorsal origin | Closer to snout than to caudal base | About equidistant from snout and caudal base |
| Peritoneum | Silvery, flecked with dusky | Dark |
| Periproct | Dark | Light |
| Scale edges on back and upper side | Narrowly edged with dark | Broadly margined with dark |
| Subpeduncular dark streak | Well defined | Faint or absent |
| Pigment on lower side of trunk | Usually present on scale edges of at least one row below lateral line | Absent or weakly developed below lateral line row |
| Chin | Light | Dark |

The records are as follows (the number of specimens, if more than one, appears in parentheses following the museum number):

*Illinois.*—INHS, lectotype, and INHS, 5 paratypes (formerly syntypes) of *Notropis anogenus* Forbes, Fox River, McHenry, McHenry County, May 8–10, 1880, presumably S. A. Forbes. INHS, Fourth Lake [Lake Co.], June 12, 1892. INHS, Havana [Mason Co.], July 7, 1909, Richardson and Hurley.

*Indiana.*—USNM 86562, no data. CU 4078

(9), UMMZ 63021 (2), USNM 125167 (27), Blue Lake, 1.5 mi. NW Churubusco, Whitley Co., July or Aug., 1892, P. H. Kirsch. CNHM 42411 (10), Creek, Hamilton Lake, Hamilton, Steuben Co., S. E. Meek. IU 508, Hamilton Lake, Hamilton, Steuben Co., Aug. 13, 1943, Shelby D. Gerking.

*Iowa.*—CNHM 943 (6), Des Moines River, Estherville, Emmet Co., about 1890, S. E. Meek. UMMZ 171264 (8), north end of West Lake Okoboji, Dickinson Co., Aug. 24, 1956, Tom Moen. UMMZ 173782, Little Millers Bay, West Lake Okoboji, Dickinson Co., June 18, 1958, V. E. Dowell.

*Michigan.*—UMMZ 67546 (20), Thunder Bay River, Alpena, Alpena Co. UMMZ 67629 (13), lower S. Br. Thunder Bay River, T. 31 N., R. 7 E, sect. 28, Alpena Co. UMMZ 145073 (10), Fish Lake, Barry Co. UMMZ 166505 (2), Bartholemew Lake, Branch Co. UMMZ 166507 (2), Marble Lake, Branch Co. UMMZ 137647, S. Br. Kalamazoo R., S. E. Homer, Calhoun Co. UMMZ 164207 (6), Hart Lake, Calhoun Co. UMMZ 116204, Cheboygan R., Cheboygan, Cheboygan Co. UMMZ 97991 (4) and 98014 (6), Fifth (or Boot) Lake, Hillsdale Co. UMMZ 98015, Fourth Lake, Hillsdale Co. UMMZ 111866, Gull Lake, Kalamazoo Co. UMMZ 164206, Maston Lake, Kent Co. UMMZ 169679 (13) and 169680 (4), Murray Lake, Kent Co. UMMZ 158539, S. Lake Leelanau, Leelanau Co. UMMZ 89957, Cleveland Lake, Lenawee Co. USNM 68660, mouth Milk R., Lake St. Clair, Macomb Co. UMMZ 110390, Dickson Lake, Manistee Co. UMMZ 164110, Chippewa Lake, Mecosta Co. UMMZ 71260 (6), Pickerel Lake, Newaygo Co. UMMZ 111894 (2), Hess Lake, Newaygo Co. UMMZ 164117 (2), Robinson Lake, Newaygo Co. UMMZ 164377, Robinson Creek, Newaygo Co. UMMZ 81980 (12), Maceday Lake, Oakland Co. UMMZ 160265, Orchard Lake, Oakland Co., UMMZ 160266 (2), Walnut Lake, Oakland Co. UMMZ 69889 (2), Onatoga Lake, Otsego Co. UMMZ 67682, Sunken Lake, Presque Isle Co. UMMZ 160789 and 164202 (3), Saddle Lake, Van Buren Co. USNM 68746 (8), Fox Cr., Detroit [Wayne Co.].

*Minnesota.*—REJ, Farm Island Lake, Aitkin Co. UMMZ 94840 (35), Mississippi R., between Cass Lake and Bemidji, Beltrami Co. REJ, Wolf Lake, Beltrami and Hubbard cos. REJ (11), Big Lake, Beltrami Co. REJ (16) Cass Lake, Beltrami and Cass cos. REJ (10), Lake Andrusia, Beltrami and Hubbard cos. REJ, Clearwater Lake, Carver Co. REJ, Maple Lake, Douglas Co. REJ (5), Lake Miltona, Douglas Co. REJ, Lake Irene, Douglas Co. REJ (3), Lake Geneva, Douglas Co. REJ, Lake Cowdry, Douglas Co. REJ, Lake Ida, Douglas Co. UM 16663, N. Br. Root River, Fillmore Co. UMMZ 72045, Minnesota R. about 8 miles above mouth, Hennepin Co. JBM, Clear Lake, Hennepin Co. REJ (10), Fish Lake, Hennepin Co. REJ, Trout Lake, Itasca Co. REJ, Lake Washington, Meeker Co. REJ (2), Dead Lake, Ottertail Co. REJ, Long Lake, Ottertail Co. UMMZ 141706 (3) and UM 14139 (20), McCarrons Lake, Ramsey Co. JBM, Floodwood Lake, St. Louis Co. THC, Grand Lake, Stearns Co. UM 17847, St. Olaf Lake, near Waseca, Waseca Co. JBM, Forest Lake, Washington Co. REJ (2), Clearwater R., 0.5 mi. above Clearwater Lake, Wright Co. REJ, Clearwater Lake, Wright Co. REJ (11), Howard Lake, Wright Co.

*New York.*—UMMZ 95695, French Cr., Clayton, Jefferson Co., July 17, 1931, S. C. Bishop. Records of this species from Irondequoit and Little Sodus bays, Lake Ontario (Greeley, 1940:74) have been included on Fig. 1.

*North Dakota.*—CNHM 35004–18 (15) and UMMZ 61945 (2), Sheyenne (Cheyenne) R., Lisbon, Ransom Co., July 26, 1892, A. J. Woolman.

*Ohio.*—UMMZ 87483 (12), East Harbor, Ottawa Co., June 24, 1929, R. C. Osburn. OSM (many lots, 56 spec.), East Harbor, Ottawa Co., June 24–Aug. 27, 1929, Osburn and E. L. Wickliff. USNM 69524, Lake Erie, Port Clinton, Ottawa Co., July 23, 1894, C. Rutter. OSM F208, Lake Erie, Port Clinton, Ottawa Co., Sept. 5, 1927, M. B. Trautman and Robert Foster.

*Ontario.*—UMMZ 130910 (23), E. shore of larger lake on Pt. Peleé, Point Peleé National Park, Essex Co., Aug. 31, 1940, C. L., L. C., and Clark Hubbs. ROMZ 14055 (70), lake in Point Peleé Park, Essex Co., July 13, 1941, J. R. Dymond. ROMZ 14056 (52), Rondeau Bay, Lake Erie, Kent Co., July 13, 1941, Dymond. UMMZ 130932 (19), Rondeau Harbor, S. E. shore just outside Provincial Park, Kent Co., Aug. 31, 1940, Hubbs party. UMMZ 104540, St. Lawrence R., Gananoque, Leeds Co., July 21, 1937, G. C. Toner. UMMZ 107901, below falls, Gananoque R., Gananoque, Leeds Co., Apr. 25, 1935, Toner. USNM 58625 (2), Lakeside, July 28, 1894, Rutter.

*Wisconsin.*—UMMZ 77824 (10), mouth of Yellow R., ¼ mi. N. Danbury, Burnett Co. UMMZ 77867, Clam R., 7 mi. W. Webster,

Burnett Co. UMMZ 77909, St. Croix R., 5 mi. W. Grantsburg, Burnett Co. UMMZ 96213, Clam R., 3 mi. S. Webster, Burnett Co. UMMZ 73573, outlet of Spring Lake, Pardeeville, Columbia Co. UMMZ 73592 (4), Park Lake, Columbia Co. UMMZ 73716 (2), Fox R. below mouth of French Cr., Columbia Co. UMMZ 73538 (23), Neenah Cr., Oxford, Marquette Co. UMMZ 74377, outlet Mason Lake, Marquette Co. USNM 88348, Turtle Cr., Delevan, Walworth Co., UMMZ 74053 (6), Blake Cr., 5 mi. W. Symco, Waupaca Co. Records from Dane and Kewaunee counties, mapped by Greene (1935:95), have been accepted on his authority without re-examination. All other identifications of *N. anogenus* by Greene were found to be correct.

### Literature Cited


Bailey, Reeve M. 1954. Distribution of the American cyprinid fish *Hybognathus hankinsoni* with comments on its original description. *Copeia 1954(4): 289–291, fig. 1.*

Forbes, S. A. 1885. Description of new Illinois fishes. *Bull. Ill. State Lab. Nat. Hist 2(2): 135–139.*

Greeley, J. R. 1940. Fishes of the watershed with annotated list. *In:* A biological survey of the Lake Ontario watershed. *Suppl. 29th Ann. Rept. (1939), N. Y. Cons. Dept.: 42–81, col. pls. 1–4.*

Greeley, John R., and Sherman C. Bishop. 1932. Fishes of the area with annotated list. *In:* A biological survey of the Oswegatchie and Black river systems. *Suppl. 21st Ann. Rept. (1931), N. Y. Cons. Dept.: 54–92, col. pls. 1–12, figs. 1–3.*

Greene, C. Willard. 1935. The distribution of Wisconsin fishes. *Wisc. Cons. Comm. 235 pp., 96 maps.*

Haas, Robert L. 1943. A list of the fishes of McHenry County, Illinois. *Copeia 1943(3): 160–164, fig. 1.*

Trautman, Milton B. 1957. The fishes of Ohio. *Ohio State Univ. Press, Columbus: xviii + 683, col. pls. 1–7, figs. 1–172, maps 1–172.*


Museum of Zoology, University of Michigan, Ann Arbor, Michigan

# The Draconettidae—A Review of the Family with the Description of a New Species*

John C. Briggs and Frederick H. Berry

THIS contribution was initiated by our attempt to identify a strange, elongate, callionymid-like fish recently taken by the U.S. Fish and Wildlife Service vessel *Combat* off the east coast of Florida just beyond the edge of the Continental Shelf.

The only description in the literature that seemed to fit our specimen was of *Draconetta acanthopoma* Regan (1904:130). This tentative identification was verified through supplementary information provided by Dr. Denys W. Tucker, who kindly re-examined the type (the only known specimen) in the British Museum (Natural History). In his brief original description, Regan (*loc. cit.*) gave the locality of capture as simply "the North Atlantic" but did state that the individual was sent to the British Museum by the Smithsonian Institution as an example of *Callionymus himantophorus* Goode and Bean. Fortunately, along with the type, Dr. Tucker found a tag bearing the number 45752. This was then traced, through the help of Dr. Ernest A. Lachner, to a jar in the U. S. National Museum containing a collection, originally labeled *Callionymus himantophorus*, taken by the *Albatross* at 30°47′30″N., 79°49′00″W. from 270 fathoms on May 5, 1886. Thus, some 54 years after the original description, we are able to provide information about the type locality and date of collection for the species *Draconetta acanthopoma* Regan. These data, and those provided by the additional specimens reported on in this paper, give the first definite New World record for this rare percomorph family (Draconettidae).

A search of other *Combat* fish collections produced 22 additional specimens of *D. acanthopoma*, and two more *Albatross* individuals were found in the U.S. National Museum. This enables us to give a relatively detailed description of this species plus some information about its range.

Before this material was ready for publica-

* Contribution No. 38, U. S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Biological Laboratory, Brunswick, Georgia.

tion, the U.S. Fish and Wildlife Service vessel *Oregon* returned from an exploratory fishing trip off the coast of northeastern South America. Dr. Giles W. Mead called out attention to the presence of a form of *Draconetta* at the U.S. National Museum in some of the collections from that cruise. These and other individuals from the *Oregon* cruise proved to be an undescribed species of *Draconetta* represented by a total of 63 specimens.

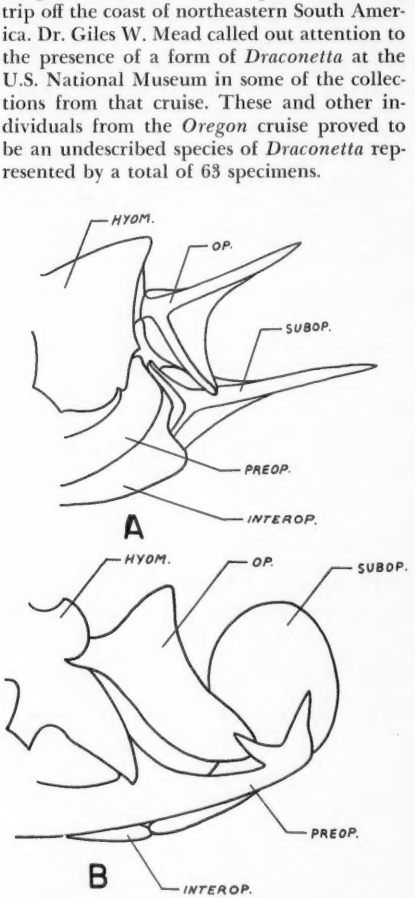



Fig. 1.—Opercular region. A, *Draconetta oregona*. B, *Callionymus himantophorus*. HYOM., hyomandibular; OP., opercular; PREOP., preopular; INTEROP., interopercular; SUBOP., subopercular.

With such adequate material, certain aspects of the osteology of the two species were investigated with the intended purpose of clarifying the relationship of the Draconettidae with the Callionymidae. A study of the external morphology alone had given rise to some feeling of doubt about the usual familial separation of *Draconetta*, but this was resolved upon examination of the cleared and stained specimens. The following abbreviations are used under the accounts of species in the text: ANSP, Academy of Natural Sciences of Philadelphia; CNHM, Chicago Natural History Museum; MCZ, Museum of Comparative Zoology, Harvard; SAFI, South Atlantic Fishery Investigations, Brunswick; SU, Natural History Museum, Stanford; TU, Tulane University, New Orleans; UBC, University of British Columbia, Vancouver; UF, University of Florida, Gainesville; USNM, United States National Museum, Washington, D. C.

## Family Relationships

The most widely used general fish classification at present is that of Berg (1947). He includes the families Draconettidae and Callionymidae in a separate suborder equivalent to Regan's (1913:144) "Division Callionymiformes." Unfortunately, Berg had no new information about either family and based his description of the suborder upon such information as was available in the literature.

Regan (*loc. cit.*) had a single specimen of *Draconetta* (*D. acanthopoma*) at hand but no skeletal material of this genus. Apparently, all of Starks' (1923:267; 1926:301; 1930:222) findings were based on a skeletal preparation of *Callionymus valenciennesi* Temminck and Schlegel, and Gregory (1933:362) examined only a skull of *C. lyra* Linnaeus. Consequently, Berg's (1947:481) osteological analysis of his suborder Callionymoidei is based only on Regan's sparse early work plus the more recent literature descriptions of two species belonging to the genus *Callionymus*. In view of this, it is not surprising that our examination of cleared and stained preparations of the two Atlantic species of *Draconetta* has revealed the need for some major changes in Berg's analysis.

As Regan (1913:145) has pointed out, the Draconettidae may be distinguished by some obvious external differences: the preoperculum is entire while the operculum and suboperculum bear strong spines (Fig. 1 A). In *Callionymus* the preoperculum is produced posteriorly as a very strong spine (Fig. 1 B) which may have various kinds of points and shapes, depending on the species; and the opercular and subopercular elements are moderately developed, rounded, and bear no armature.

Gregory (1933:361) found that in *Callionymus lyra* the ascending processes of the premaxillae are received posteriorly into a deep fossa formed chiefly by the lateral ethmoids. Berg (1947:481), with a change in nomenclature, applied this characteristic to the en-

tire suborder. However, we find no indication of such a modification in *Draconetta*.

Starks (1923:268; 1930:222) discovered that the supracleithrum was missing in *Callionymus valenciennesi* Temminck and Schlegel, and he provided a figure (1930, fig. 32) of the pectoral girdle which showed a total of three radials suturally joined to one another. Berg (*op. cit.*) also utilized these characteristics for the suborder Callionymoidei, and, in so doing, followed Gregory's misinterpretation of Starks' drawing saying that the scapula formed a bridge between the three expanded radials. However, in both *Draconetta* and *Callionymus himantophorus* the supracleithrum is rather simple compared to the heavier, plate-like structures (Fig. 3 B) found in *Callionymus*.

Considering the paucity of our knowledge about these two families and their relationships with other percomorph groups, we see no present need for setting them aside in a separate suborder. Their morphology is no more peculiar than that of several other families which are traditionally retained without subordinal recognition within the vast assemblage of the Percomorphi.

On the basis of our examination of the *Draconetta* specimens and a direct comparison with *Callionymus himantophorus*, we be-

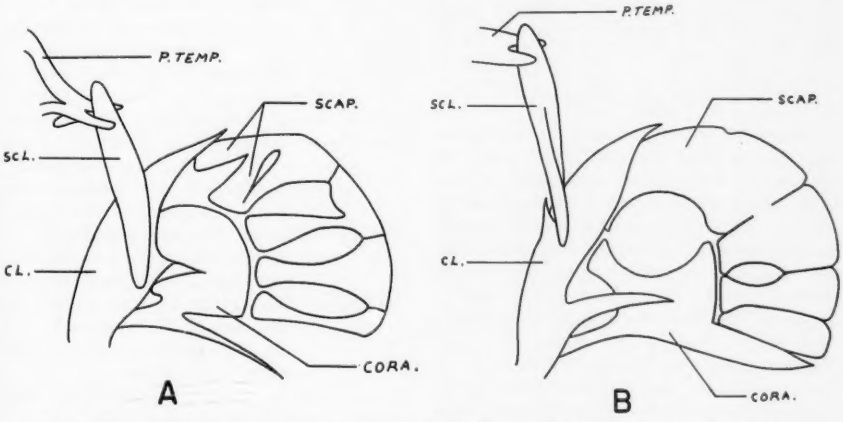



Fig. 2.—Pectoral girdle. A, *Draconetta oregona*. B, *Callionymus himantophorus*. CL., cleithrum; CORA., coracoid; P. TEMP., postemporal; SCL., supracleithrum; SCAP., scapula.

present and well developed, and in neither does the scapula form a bridge between the radials. In addition, four radials, widely separated by foramina, are apparently recognizable in *Draconetta* (Fig. 2 A). In *Callionymus himantophorus*, the radials have been reduced to three (Fig. 2 B), presumably by fusion of the uppermost element to the scapula. It also should be noted (Fig. 2 B), that the latter species possesses a single large interradial foramen.

Regan (1913:145) stated that the Callionymidae possessed 21 vertebrae, and Starks (1923:269) observed that the vertebral column was peculiar in that the neural and haemal spines were plate-like. These characters were also used by Berg (*op. cit.*) to define the suborder, but they are not characteristic of the Draconettidae. Our cleared and stained specimens of *Draconetta* revealed 23 vertebrae and neural and haemal spines (Fig. 3 A) that were

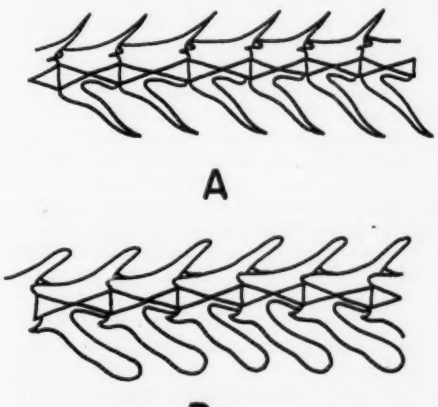



Fig. 3.—Section of caudal vertebral column. A, *Draconetta oregona*. B, *Callionymus himantophorus*.

lieve that these genera do represent distinct, but closely related, families. They may now be best defined as follows:

### Family Callionymidae[1]

Gill opening reduced to a small foramen on upper side of head; operculum and subopercular entire; preoperculum bearing a very strong spine; anterior cranial bones forming a deep groove for the receipt of the ascending processes of the premaxillaries; three radials in pectoral girdle closely joined to one another; 21 vertebrae with neural and haemal spines plate-like and split at the ends for articulation with the dorsal and anal pterygiophores; dorsal fin spines usually 4; dorsal fin soft rays 6 to 11; anal fin soft rays 4 to 10.

### Family Draconettidae

Gill opening comparatively broad, extending from a point about opposite upper pectoral edge to just above pelvic base; operculum and subopercular each bearing a strong straight spine; preoperculum entire; anterior cranial bones not forming a deep groove for the receipt of the ascending processes of the premaxillaries; four radials in pectoral girdle separated by large foramina; 23 vertebrae with neural and haemal spines of normal shape and not articulating directly with the dorsal and anal pterygiophores; dorsal fin spines 3; dorsal fin soft rays 12 to 15; anal fin soft rays 12 to 13.

Aside from the bones of the opercular series (which are difficult to evaluate in terms of relative specialization), the general morphology of the Draconettidae indicates that it is the most primitive of the two families and, perhaps, should be considered close to the ancestral line of the Callionymidae. Such characteristics as the large gill opening, unmodified anterior cranial bones, four pectoral radials, a larger number of vertebrae with unspecialized spines, a greater number of dorsal and anal fin rays, and a larger over-all size, are suggested as evidence of a relatively primitive status for the Draconettidae.

### Genus *Draconetta* Jordan and Fowler

*Draconetta* Jordan and Fowler, 1903, p. 939 (type species *Draconetta xenica* Jordan and Fowler, 1903, by original designation).

[1] This family is much in need of revision, and, since this characterization is based mostly upon our knowledge of the genus *Callionymus*, it is quite likely that our definition of this family may be expanded or altered with such revision.

*Centrodraco* Regan, 1913, p. 145 (type species *Draconetta acanthopoma* Regan, 1904, by original designation).

### Artificial Key to the Species of Draconetta

1a. Pectoral fin rays 16 ..... *pseudoxenica* (p. 126).

1b. Pectoral fin rays 20–27.

2a. Dorsal soft rays 12, anal soft rays 12 ..... *xenica* (p. 127).

2b. Dorsal soft rays 14–15, anal soft rays 13.

3a. Caudal peduncle relatively deep, 6.3–7.4 percent of standard length; first dorsal spine 4.9–6.4 percent of standard length; lateral line extending posteriorly to below 6th to 7th dorsal soft ray; dark rounded spots and blotches on side of body; no sexual dimorphism ..... *acanthopoma* (p. 127).

3b. Caudal peduncle relatively slender, 4.7–6.1 percent of standard length; first dorsal spine 6.9–19.7 percent of standard length; lateral line extending posteriorly to below 10th to 12th dorsal soft ray; narrow longitudinal dark spots on side of body; marked sexual dimorphism ..... *oregona* (p. 129).

### *Draconetta pseudoxenica* Kamohara

*Draconetta pseudoxenica* Kamohara, 1952, p. 88, fig. 86 (Mimase, Prov. Tosa).—Matsubara, 1955, p. 710 (key to Japanese species of *Draconetta*).

*Diagnosis.*—A *Draconetta* with a light reddish base color, paler below; back spotted with greenish; base of pectoral red. The following measurements are given as a percentage of standard length: First dorsal spine 4.2, second dorsal spine 7.9, third dorsal spine 4.7, first dorsal soft ray 14.2, longest dorsal soft ray (the second) 14.7, first anal soft ray 5.8, longest anal soft ray (the ninth) 8.4, pectoral fin length 22.1, and pelvic fin length 21.0. Dorsal III-14; anal 13; pectoral 16.

*Relationship.*—Probably most closely related to *Draconetta xenica* but its reduced number of pectoral rays plus its more numerous dorsal and anal rays allow it to be easily distinguished.

*Remarks.*—This species is known only from

the holotype deposited in the Biological Laboratory of the Kôchi Kôtô Gakkô.

*Range*.—Mimase, Tosa Bay, Japan.

*Draconetta xenica* Jordan and Fowler

*Draconetta xenica* Jordan and Fowler, 1903, p. 939, fig. 1 (Suruga Bay at 100 fathoms).—Jordan and Starks, 1904, p. 589, fig. (reference to same specimen).—Kamohara, 1952, p. 88 (Mimase, Prov. Tosa).—Matsubara, 1955, p. 710.

*Draconetta hawaiiensis* Gilbert, 1905, p. 652, pl. 91 (channel between Molokai and Maui at 122–132 fathoms).—Jordan and Seale, 1906, p. 415 (reference to same specimen).—Fowler, 1928, p. 422 (reference to same specimen).

*Diagnosis*.—A *Draconetta* with a pale brown base color; back and side mottled and spotted with dark brown; a blackish band extending from base of spinous dorsal to behind pectoral base; spinous dorsal blackish. The following measurements are given as percentages of standard length: First dorsal spine 14.8–20.6, second dorsal spine 12.5–17.8, third dorsal spine 10.3–15.5, first dorsal soft ray 13.2–19.6, longest dorsal soft ray (10th) about 20.6, first anal soft ray 7.4–8.2, longest anal soft ray (8th) 13.4–14.0, pectoral fin length 20.6–26.7, and pelvic fin length 22.7–24.0. Dorsal III-12; anal 12; pectoral 20–23.

*Relationship*.—Seems to be closest to *Draconetta pseudoxenica* but has more pectoral rays and fewer dorsal and anal rays.

*Remarks*.—This species is known only from three specimens, the holotype of *D. xenica* deposited in the U. S. National Museum (No. 50816), the holotype of *D. hawaiiensis* at the same institution (No. 51633), and an individual reported by Kamohara (1952:88) in the Biological Laboratory of the Kôchi Kôtô Gakkô.

*Range*.—Japan to Hawaii.

*Draconetta acanthopoma* Regan

Figure 4

*Draconetta acanthopoma* Regan, 1904, p. 130 (the North Atlantic).—Jordan, Evermann and Clark, 1930, p. 450 (North Atlantic, in deep water).

*Centrodraco acanthopoma* Regan, 1913, p. 145 (the North Atlantic).

*Diagnosis*.—A *Draconetta* with a distinctive color pattern consisting of rounded spots and blotches on the side of the body. Lateral line fine, extending from the upper attachment of the gill membrane posteriorly to a position below the 6th to 7th dorsal soft ray. Caudal peduncle relatively deep, 6.3–7.4 percent of standard length. First dorsal spine 4.9–6.4 percent of standard length (Fig. 5). Longest anal soft ray (usually the 13th) 8.0–10.4 percent of standard length. No externally apparent sexual dimorphism. Dorsal III-14 to 15; anal 13; pectoral 25–26.

*Description*.—The following measurements are given as a percentage of standard length: Head length 32.4–36.8, eye diameter 11.4–15.2, snout length 7.7–9.4, upper jaw length 8.5–10.0, body depth at pelvic origin 12.6–16.9, snout to pectoral origin 31.1–35.8, snout to pelvic origin 27.1–30.7, snout to first dorsal spine 32.3–36.8, snout to first anal soft ray 51.8–55.6, body depth at first anal soft ray 10.9–14.1, second dorsal spine 8.6–10.1, third dorsal spine 4.7–6.8, first dorsal soft ray 10.3–13.6 (Fig. 6), longest dorsal soft ray (usually the 3rd) 12.1–13.6, pectoral fin length 22.9–27.2, pelvic fin length 22.3–31.1.

External sexual dimorphism is not apparent in our specimens which range from 47.5 to 99 mm. standard length—its possible manifestation at larger sizes is presently indeterminate.

*Coloration*.—Dark rounded spots and irregular blotches on the side of the body; a few small spots on head and nape with a large rounded dark area on the operculum; a single rounded mass of dark pigment at the caudal base; all pigment very faded on some specimens; usually some melanophores scattered on the membranes of both the spinous and soft dorsal fins, but the interspinous membranes very dark on some specimens; the pectoral, anal, and pelvic fins unpigmented; a single fresh-caught specimen noted with scarlet body spots and light rose colored body.

*Relationship*.—Most closely related to the following species but readily separated from it by the characters listed in the diagnosis and the key to the species.

*Range*.—Off the east coast of the United States beyond the edge of the Continental Shelf at depths of 210 to 300 fathoms, from about 15 miles south of Key West, Florida, to about 45 miles east of Cumberland Island, Georgia.

*Material Examined*.—USNM 46105, 1 female, 72 mm. S.L., *Albatross* Sta. 2667, 30°53′ N., 79°42′30″W., about 45 miles east of Cumberland Island, Georgia, 273 fathoms, 5 May 1886.—USNM 45752, 1 specimen, 78 mm. S.L., *Albatross* Sta. 2666, 30°47′30″N., 79°49′W.,

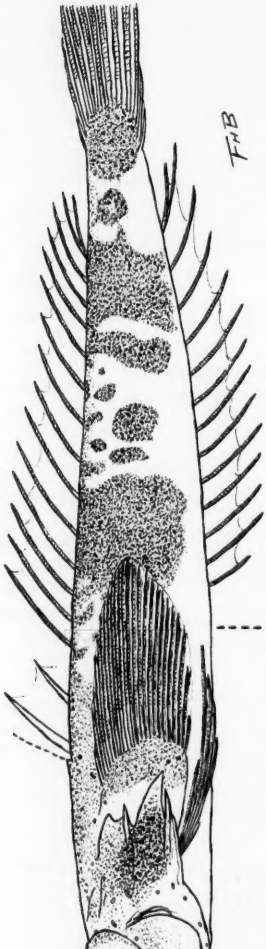



Fig. 4.—*Draconetta acanthopoma* Regan, female, 83 mm. standard length, USNM 156957.

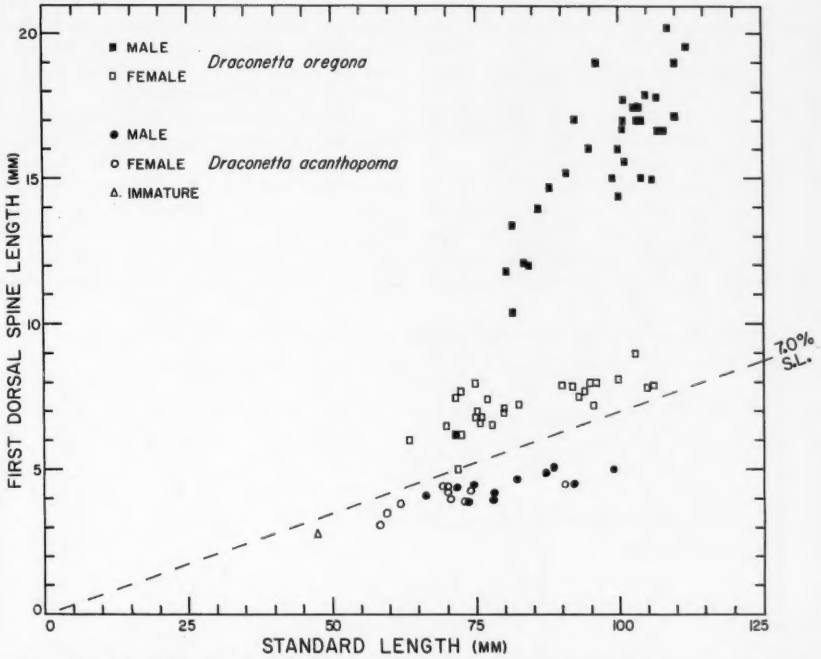



Fig. 5.—Relation of first dorsal spine length to standard length for *Draconetta oregona* and *Draconetta acanthopoma*.

about 42 miles east of Cumberland Island, Georgia, 270 fathoms, 5 May 1886.—USNM 156957, 1 female, 83 mm. S.L., *Combat* Sta. 310, 30°40′N., 79°57′W., about 77 miles east of Fernandina, Florida, 210 fathoms, 24 April 1957.—USNM 156958, 1 male, 82 mm. S.L., *Combat* Sta. 439, 25°03′N., 80°01′W., about 20 miles southeast of Key Largo, Florida, 225 fathoms, 22 July 1957.—USNM 156956, 6 males, 71.5 to 99 mm. S.L., 4 females, 58 to 90.5 mm. S.L., and 1 immature specimen, 47.5 mm. S.L., *Combat* Sta. 436, 24°13′N., 81°42′ W., about 15 miles south of Key West, Florida, 300 fathoms, 21 July 1957.—SAFI collection, 2 males (cleared and stained), 73.5 and 77 mm. S.L., *Combat* Sta. 436.—SAFI collection, 1 male, 88.5 mm. S.L., and 1 female, 74 mm. S.L., *Combat* Sta. 436.—UBC 58-308, 1 female, 73 mm. S.L., *Combat* Sta. 436.—CNHM 64460, 1 female, 70.5 mm. S.L., *Combat* Sta. 436.—UF 5246, 1 female, 70 mm. S.L., *Combat* Sta. 436.—SU 51107, 1 female, 70 mm. S.L., *Combat* Sta. 436.—ANSP 83825, 1 female, 69 mm. S.L., *Combat* Sta. 436.—MCZ 3990, 1 male, 66 mm. S.L., *Combat* Sta. 436.—TU collection, 1 male, 78 mm. S.L., *Combat* Sta. 436.

**Draconetta oregona**, *sp. nov.*

Figure 7

*Diagnosis.*—A *Draconetta* with a distinctive color pattern consisting mainly of narrow elongated spots on side of body. Lateral line fine, extending from the upper attachment of the gill membrane posteriorly to a position below the 10th to 12th dorsal soft ray. Caudal peduncle relatively narrow, 4.7–6.1 percent of standard length. First dorsal spine 6.9–19.7 percent of standard length (Fig. 5). Longest anal soft ray (usually the 13th) 10.7–13.9 percent of standard length. Externally apparent sexual dimorphism present. Dorsal III-14; anal 13; pectoral 23–27.

*Description.*—The following measurements are given as a percentage of standard length: Head length 33.6–38.0, eye diameter 10.2–13.3, snout length 7.9–10.0, upper jaw length 9.0–10.6, body depth at pelvic origin 11.2–14.8, snout to pectoral origin 32.4–35.5, snout

to pelvic origin 25.6–31.0, snout to first dorsal spine 30.9–35.5, snout to first anal soft ray 52.3–56.2, body depth at first anal soft ray 9.1–11.4, first dorsal spine 10.6–19.7 in males and 6.9–10.7 in females, second dorsal spine 7.2–10.9, third dorsal spine 4.4–7.7, first dorsal soft ray in males 18.6–50.5 and 12.4–15.8 in females (Fig. 6), longest dorsal soft ray (usually the first) in males 26.2–35.1 and 13.1–15.4 in females, pectoral fin length 22.6–27.6, pelvic fin length 24.6–35.0. Sexual differences in the soft ray lengths are apparent at 72.5 mm. standard length (size of the smallest male available) and in the spine lengths by 80 mm. standard length. These differences become quite accentuated at maturity (see Figures 5 and 6). This type of dimorphism is quite common in the Callionymidae.

*Coloration.*—Elongated longitudinal dark spots on the side of the body concentrated in two areas, one along the midline and one above and parellel to it; these tending on larger specimens to appear as interrupted stripes instead of spots; smaller, elongate, black spots distributed on the nape and on the side of the head; two more narrow longi-

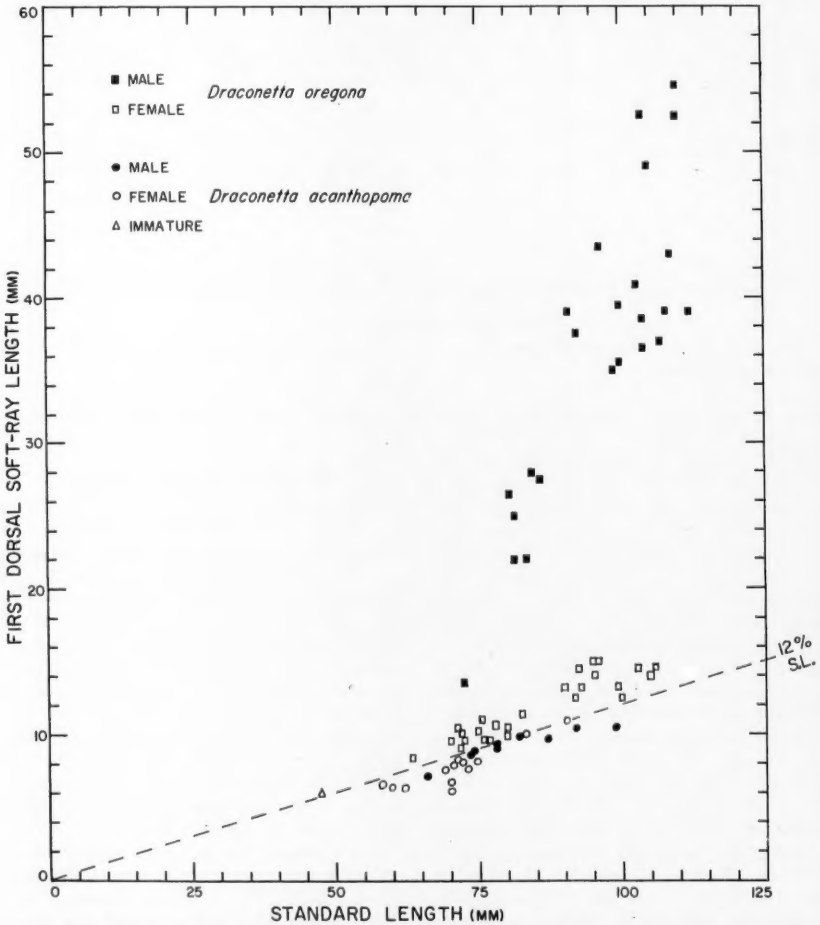



Fig. 6.—Relation of first dorsal soft ray length to standard length for *Draconetta oregona* and *Draconetta acanthopoma.*

Fig. 7.—*Draconetta oregona*. A, dorsal fin of female, paratype, 105 mm. standard length, CNHM 64387. B, holotype, male, 112 mm. standard length, USNM 159776.

tudinal dark spots on the caudal base; usually a few melanophores scattered on the membranes of both the spinous and soft dorsal fins, but the interspinous membranes dark on some specimens; the pectoral, anal, and pelvic fins usually unpigmented, but the pelvics definitely pigmented on two large specimens.

*Relationship.*—Most closely related to *Dranetta acanthopoma* but readily separated from that species by the characters listed in the diagnosis and the key to the species.

*Range.*—Off the northeast coast of South America close to the edge of the Continental Shelf at depths of 125 to 225 fathoms.

*Derivation of name.*—This new species is named *oregona* to commemorate the important work of the U.S. Fish and Wildlife Service exploratory fishing vessel *Oregon* in contributing to the knowledge of Western Atlantic ichthyology.

*Holotype.*—USNM 159776, male, 112 mm. in standard length, *Oregon* Sta. 2080, 02°04′N., 47°00′W., about 160 miles northeast of mouth of Rio Para, Brazil, 125 fathoms, 17 November 1957.

*Paratypes.*—SAFI collection, 2 males, 72.5 and 109 mm. S.L., and 1 female, 72.5 mm. S.L. (all cleared and stained), collected with the holotype.—SAFI collection, 1 male, 104 mm. S.L., and 1 female, 92 mm. S.L., collected with the holotype.—TU 188831, 3 females, 90 to 106 mm. S.L., collected with the holotype.—SU 51106, 1 female, 103 mm. S.L., collected with the holotype.—UBC 58-307, 1 male, 101 mm. S.L., collected with the holotype.—UF 5245, 1 female, 95.5 mm. S.L., collected with the holotype.—ANSP 83826, 1 female, 99.5 mm. S.L., collected with the holotype.—MCZ 39989, 1 female, 95 mm. S.L., collected with the holotype.—UMML 3300, 2 males, 105 and 110 mm. S.L., and 1 female, 93 mm. S.L., collected with the holotype.—CNHM 64386, 3 males, 96.5 to 110 mm. S.L., and 3 females, 94 to 104 mm. S.L., collected with the holotype.—CNHM 64387, 1 male, 108 mm. S.L., and 1 female, 105 mm. S.L., *Oregon* Sta. 2081, 01°52′N., 46°54′W., 175 fathoms, 17 November 1957.—CNHM 64388, 5 males, 86 to 107 mm. S.L., and 4 females, 63.5 to 80 mm. S.L., *Oregon* Sta. 2082, 01°51′N., 46°50′W., 200 fathoms, 17 November 1957.—USNM 158875, 17 males, 72.5 to 107 mm. S.L., and 11 females, 70 to 82.5 mm. S.L., *Oregon* Sta. 2082.—CNHM 64389, 1 male, 106 mm. S.L., *Oregon* Sta. 2083, 01°49′N., 46°48′W., 225 fathoms, 17 November 1957.

## Acknowledgments

We wish to thank especially three persons who kindly helped us assemble the information about this rare group of fishes: Giles W. Mead examined the types of *Draconetta xenica* and *D. hawaiiensis* at the U.S. National Museum, Denys W. Tucker examined the type of *D. acanthopoma* in the British Museum (Natural History), and Toshiji Kamohara sent us some additional information about the type of *D. pseudoxenica*. We also wish to express our appreciation to the following individuals and institutions for the loan of material: Harvey R. Bullis, Jr., U.S. Fish and Wildlife Service, Pascagoula, Miss.; C. Richard Robins, University of Miami; Leonard P. Schultz, U.S. National Museum; Royal D. Suttkus, Tulane University; Loren P. Woods, Chicago Natural History Museum. For propitious comments concerning the manuscript we thank William W. Anderson, David K. Caldwell, Jack W. Gehringer, and Giles W. Mead, U.S. Fish and Wildlife Service.

## Literature Cited

Berg, L. S. 1947. Classification of fishes, both recent and fossil. *Translation from: Travaux de l'Institut Zoologique de l'Académie des Sciences de l'U.R.S.S. 1940, 5(2): 87–517, 190 figs.*

Fowler, H. W. 1928. The fishes of oceania. *Mem. Bernice P. Bishop Mus. 10: 1–539, 82 figs., 49 pls.*

Gilbert, C. H. 1905. Deep-sea fishes. *In* Jordan, D. S., and B. W. Everman, The Aquatic resources of the Hawaiian Islands, Part 2, Section 2. *Bull. U.S. Fish Comm. for 1903, 23: i–xi, 575–713, figs. 230–276, pls. 66–101.*

Gregory, W. K. 1933. Fish skulls: a study of the evolution of natural mechanisms. *Trans. Amer. Philos. Soc. New Series 23 (Art. 2): i–viii, 75–481, 302 figs.*

Jordan, D. S., and H. W. Fowler. 1903. A review of the dragonets (Callionymidae) and related fishes of the waters of Japan. *Proc. U.S. Nat. Mus. 25: 939–959, 9 figs.*

———, B. W. Evermann, and H. W. Clark. 1930. Check list of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia. *Rept. U.S. Comm. Fish. for 1928, (10): 1–670.*

———, and A. Seale. 1906. The fishes of Samoa. Description of the species found in the archipelago, with a provisional check-list of the fishes of oceania. *Bull. Bur. Fish. for 1905, 25: 173–455, 111 figs., pls. XXXIII–XXXVII, col. pls. XXXVIII–LIII.*

———, and E. C. Starks. 1904. List of fishes dredged by the steamer *Albatross* off the coast of Japan in the summer of 1900, with descriptions of new species and a review of the Japanese Macrouridae. *Bull. U.S. Fish. Comm. for 1902, 22: 577–630, text-figs., 8 pls.*

KAMOHARA, T. 1952. Revised descriptions of the offshore bottom-fishes of Prov. Tosa, Shikoku, Japan. *Repts. Kochi Univ., Nat. Sci. (3): 1–122, 100 figs.*

MATSUBARA, K. 1955. Fish morphology and hierarchy, Part 1. *Ishizaki-Shoten, Tokyo, 789 pp., 289 figs. (in Japanese).*

REGAN, C. T. 1904. On the affinities of the genus *Draconetta*, with description of a new species. *Ann. Mag. Nat. Hist., Ser. 7, 14: 130–131.*

———. 1913. The classification of the percoid fishes. *Ann. Mag. Nat. Hist., Ser. 8, 12(67): 111–145.*

STARKS, E. C. 1923. The osteology and relationships of the uranoscopid fishes. *Stanford Univ. Publ., Biol. Sci. 3(3): 261–290.*

———. 1926. Bones of the ethmoid region of the fish skull. *Stanford Univ. Publ., Biol. Sci. 4(3): 139–338, 58 figs.*

———. 1930. The primary shoulder girdle of the bony fishes. *Stanford Univ. Publ., Biol. Sci. 6(2): 149–239, 38 figs.*

DEPARTMENT OF ANATOMY, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BRITISH COLUMBIA, AND U. S. FISH AND WILDLIFE SERVICE, BRUNSWICK, GEORGIA.

# The Role of the Senses in the Feeding of the Nocturnal Reef Predators *Gymnothorax moringa* and *G. vicinus*[1]

JOHN E. BARDACH, HOWARD E. WINN, AND DAVID W. MENZEL

OBSERVATIONS and experiments described here are part of a larger investigation on the behavior and ecology of reef fishes of Bermuda and Bimini, Bahama Islands, conducted by the authors between 1955 and 1957. Studies of long and short term movements of fishes on a reef (Bardach, 1958) and the species composition of the standing crop (Bardach, 1959) suggested that morays play a key role as predators and scavengers.

The most common representatives of this group in Bermuda are the common spotted moray, *Gymnothorax moringa* (Cuvier), and the brown moray, *G. vicinus* (Castelnau) (USNM 175813 and 175792). There is considerable uncertainty about the taxonomy of morays so that identifications must necessarily be tentative. They are easily caught in traps and survive fairly well in captivity. Field observations of their day and night activities preceded tank experiments on their diel activity patterns and other tests on the role of their senses in locating and ingesting food.

## FIELD OBSERVATIONS

At Bimini, records during 1955 of bait set out for morays, traps set during the day and during the night, and observations while diving, all pointed to a very set and typical behavior pattern of several species of morays. The fishes stay hidden under ledges or in crevices during the day but they come out and forage at night. Their heads can then be seen projecting out of their hiding places, even to a length of two or three feet. They can be tempted to leave their retreats during the day if they are offered rotten fish or conch as bait, but even then they quickly return for cover.

Many daytime observations from the Bermuda reefs revealed very similar behavior and confirmed that the morays are rarely out of their hiding places during the day and will forage only if offered the strong incentive of ripe bait such as dead fish. Observations were made at night with glass bottom buckets and automobile seal-beam light and morays were seen to slide across the field of vision on several occasions. The records of catches in wire traps were similar to those obtained in Bimini. Morays were frequently caught overnight but only very rarely during the daytime. The poisoning of a small reef area furnished us with an unexpectedly great number of morays—more than 60 small and 25 large members of the two species were collected. These fish are normally well hidden in the coral recesses.

## MATERIALS AND METHODS OF LABORATORY EXPERIMENTS

Several morays of the two common local species were kept in tanks with flowing sea water during the summers of 1956 and 1957 at the Bermuda Biological Station for Research. The animals were between 50 and 90 cm. long

[1] Contribution 241, Bermuda Biological Station for Research, supported by a grant from the National Science Foundation. We thank the Director and Station personnel for their aid.

and weighed between 400 and 1700 g. During the experiments they were kept in wooden tanks, 120 cm. by 50 cm. by 40 cm., with a plate glass window on one long side for observation. Tanks were lined with a black asphaltum paint, sea water flowed through them from one end to the other, and they were covered with weighted galvanized chicken wire to prevent the escape of the morays. Two piles of rocks were placed at either end of the long sides of the tank, piled in such a manner that they formed a covered area where the moray could hide and stick its head out into the tank. This simulated natural conditions of a recess in the reef. The fish soon chose a hole as its "home" and returned there after performing a test or foraging at night.

TABLE 1

SUMMARY OF FEEDING TESTS WITH BEAKERS ON NORMAL COMMON SPOTTED MORAYS (*G. moringa*)

Bermuda, 1956

| (Aug. 3–18) | No. of Tests: Moray 1 | Ave. No. of Scanning Movements (20 min.) | No. of Tests: Moray 2 | Ave. No. of Scanning Movements (20 min.) |
|---|---|---|---|---|
| Feeding tests | 10 | 7.0 | 10 | 4.0 |
| Control observations | 3 | 1.0 | 4 | 0.25 |

In order to obtain a graphic record of a moray's day and night activity patterns, four paddles of 4 mm. (¼ inch) clear lucite, 8 cm. high, were mounted on an axle which turned in a pin-point cup on the bottom of the wooden tank. The lucite blades, which extended across the aquarium, were perforated with about 1-cm. holes to allow for easier turning against resistance of the water. The shaft turned in a delicate ball bearing which was firmly supported in the tank with a board. A bevelled wheel transmitted the turning movements to a kymograph stylus and a slowly revolving smoked drum. Because of the demersal swimming habits of the moray, the wheel was turned every time the fish moved farther than half way across the tank. Normal fish and blinded fish in natural light conditions and morays kept under a 24-hour regime of darkness were tested.

For tests on the sense of smell a one liter pyrex beaker was partly filled with crushed small clupeid fishes locally called "anchovy" (*Sardinella anchovia*). Sea water was added to the rim of the beaker and it was covered with small plastic hardware cloth, held in place with a draw string. This string also served to lower the beaker into the aquarium near the water inflow at the opposite end from the moray's hiding place. Small particles and the "juice" of crushed fish diffused across the tank and reached the opposite end in 30 to 50 seconds. Usually only one test was given per day, but occasionally there were two, separated by several hours. Other tests were made by introducing only the "juice" by means of a syringe so that no jarring of the tank occurred. Control observations representing sham-feeding were made by placing the same beakers, filled with sea water only, in the customary test position, or by introducing sea water instead of fish juice through a syringe.

Records were taken by either one or two experimenters for 20 minutes after the introduction of the food. The records included the time it took the fish to reach the food-beaker or the place where the juice was introduced. The variations in number of head movements were also recorded; these were termed "scanning movements" (Table 1) because the animal appeared to try to test a large volume of water without actually changing the position of most of its body.

The fish were tested: a) with all senses intact; b) deprived of their sense of smell; and c) blinded with plugged nares. The sense of smell was eliminated by inserting a thin roll of cotton into the anterior nares until it came out at the posterior nasal opening. Imbibition of the cotton soon prevented passage of water over the olfactory epithelium. The eyeballs were cut out in order to blind the fish; in one case 0.03 cc. of full strength Phemerol was injected into the posterior chambers of the eyes, the eyes degenerated within a few weeks. MS222 was used as anesthetic in these operations. In addition, taste and touch were investigated as follows: Five different normal morays in seven tests were offered one, two or three paraffin-coated, together with one to three uncoated, anchovies. The uncoated anchovies provided the smell stimulus to send the fish on its search for food, at the far end of the tank. The morays were able to differentiate between the treated and untreated food and their behavior gave a clue as to what role taste and touch stimuli played in ingestion.

## LABORATORY OBSERVATIONS OF 24-HOUR ACTIVITY PATTERNS

The field observations had suggested that the animals are predominantly active at night.

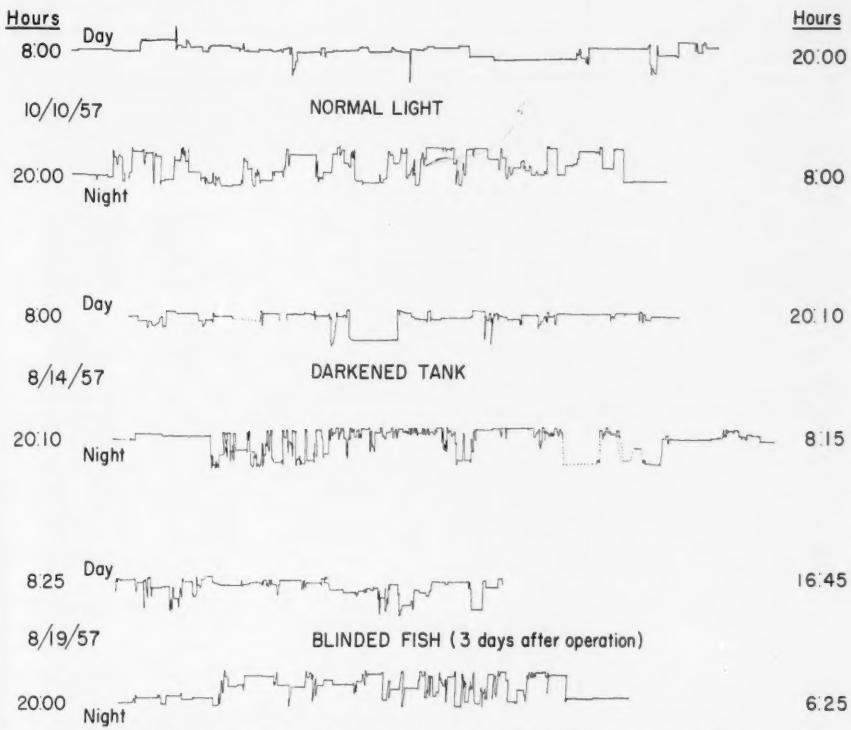



**Fig. 1.—24-hour activity records of 3 different common spotted morays, Bermuda, Summer 1957; up and down strokes represent swimming at least one-half way through tank; the more vertical strokes, the more activity.**

Normal fish, normal fish in darkened tanks, and blinded fish furnished the kymograph tracings of Fig. 1. Up and down strokes of the pen indicate fish movements caused by the turning of the paddlewheel as the moray swam over it. Normal fish became more active with the onset of darkness between 6 and 7 PM. In the darkened tank this, possibly preconditioned, two-phase activity pattern became less pronounced but was not completely erased; this also applied to the blinded fish, which even 3 days after the operation appeared still to be somewhat more active at night than during the day.

In the case of the darkened tank there might have been an undetected light leak, and in the case of the blinded fish the exposed optic nerve or the top of the head might have been light sensitive. On the other hand, internal rhythms not secondarily dependent on external stimuli have been demonstrated for many activities of a large number of animals (e.g., Browman, 1952; Brown, Webb, Bennett, and Sandeen, 1954). Even if there is no internal rhythm independent of external stimuli, there is a possibility that conditioning in nature has set up a periodic behavior pattern which perseveres although the stimulus for it is absent. Longer periods would be necessary to establish whether the differential rates of activity could finally be erased by continuous darkness. No records were obtained in uniform continuous light.

### Experiments on Sensory Physiology

As has been mentioned, sight, smell, taste, and touch were investigated for their relative importance in feeding. The temperature sense, hearing, and the lateral-line sense were neglected because all food of this fish is isothermal to the environment and because the last two senses are difficult to block without considerable trauma to the animal. Tables 1 and 2 summarize most of the sight and smell

tests. A number of reactions were used in them, depending on whether the fish came straight from the reef (Table 1) or whether they had been held in tanks for some time (Table 2).

Newly caught fish were very retiring and hardly moved from their hiding places. Their head movements, therefore, were the best indication that they had been alerted by the food stimulus. Fish from holding tanks, where they had been fed, had already learned to associate anchovies with food and reacted fast and decisively by swimming to the place where the beaker was introduced.

TABLE 2

SUMMARY OF FEEDING TESTS WITH BEAKERS ON BLINDED COMMON SPOTTED MORAYS (*G. moringa*) Bermuda, 1956

| | No. of Tests: Moray 1 | Minutes to reach beaker (average) | No. of Tests: Moray 2 | Minutes to reach beaker (average) |
|---|---|---|---|---|
| (Sept. 1–18) | | | | |
| Feeding tests, sense of smell intact | 13 | 3.4 | 14 | 15.8 |
| Feeding tests (nares plugged) | 2 | 20.0 | 2 | 20.0 |
| Control observations | 2 | 20.0 | 2 | 20.0 |
| | Moray 3 | | Moray 4 | |
| (Aug. 20–Oct. 20) | | | | |
| Feeding tests, sense of smell intact | 16 | 9.4 | 16 | 3.4 |
| Feeding tests, (nares plugged) | 4 | 20.0 | 6 | 19.4 |
| Control observations | 5 | 18.8 | 5 | 12.0 |

Morays also became used to their experimental tanks and after a week or two occasionally explored their environment without the food stimulus; this is reflected in the shorter average control times in Table 2, especially for Moray No. 4.

In addition to these tests, there are some observations not shown in the tables in which only "juice" was introduced to blinded morays by means of a glass tube and a syringe. The average time in which they reached the food-end of the tank was 2 minutes and 35 seconds for seven tests. In several control observations, where sea water was used instead of fish juice, the animals did not move out of their homes and, therefore, their score was twenty minutes; that is, they did not move during the entire observation period. This reinforces the data of Tables 1 and 2.

The pattern of testing involved several steps, such as approaching the experimental tanks, the lifting of the wire cover, and the immersion of the beaker. All these might have served as conditioning prior to the introduction of the intended simulus. This does not seem to be a valid objection because sham-fed morays did not search for food during control tests. In addition, the introduction of only juice could be done without jarring or lifting of tank covers. A distinct reaction occurred only after the introduction of a substance detectable with chemical senses.

These observations and the tabular data showed that sight is of no, or very minor, importance in food finding because blinded fish reacted like fish with their sight intact. Smell certainly seems of greatest importance in locating food at a distance as shown by the difference in behavior between morays with open and plugged nares.

MacGinitie and MacGinitie (1949:395–96) gave corresponding observations in their description of the effect of octopus ink on the sense of smell of the Pacific moray, *G. mordax*. Octopus is a favorite food but also an enemy of this species; introduction of ink into tanks where the fish were kept resulted in an anesthesis of their chemical senses for one to two hours. The morays would seek for the octopus in their tanks but could not locate it, they would even fail to react if they bumped into the octopus accidentally.

Such preponderance of one sense over others in relation to a fish's habits and habitat has been described by Wunder (1927) for various freshwater species. Hasler (1954) reviewed olfactory perception in fishes and cited several sources which suggest that chemical senses are more important than sight in a number of species which live in turbid waters or are bottom dwellers. Our data show that some nocturnal or crepuscular fishes have evolved similar adaptations.

So far we have, however, only dealt with the manner in which the morays locate their food. Once located it has to be ingested. It is reasonable to assume that other senses than smell, namely taste and touch, become important in this second phase of feeding. These senses were investigated by letting morays select from simultaneously offered paraffin coated and uncoated anchovies (see MATERIALS AND METHODS OF LABORATORY EXPERIMENTS). The following description, with mi-

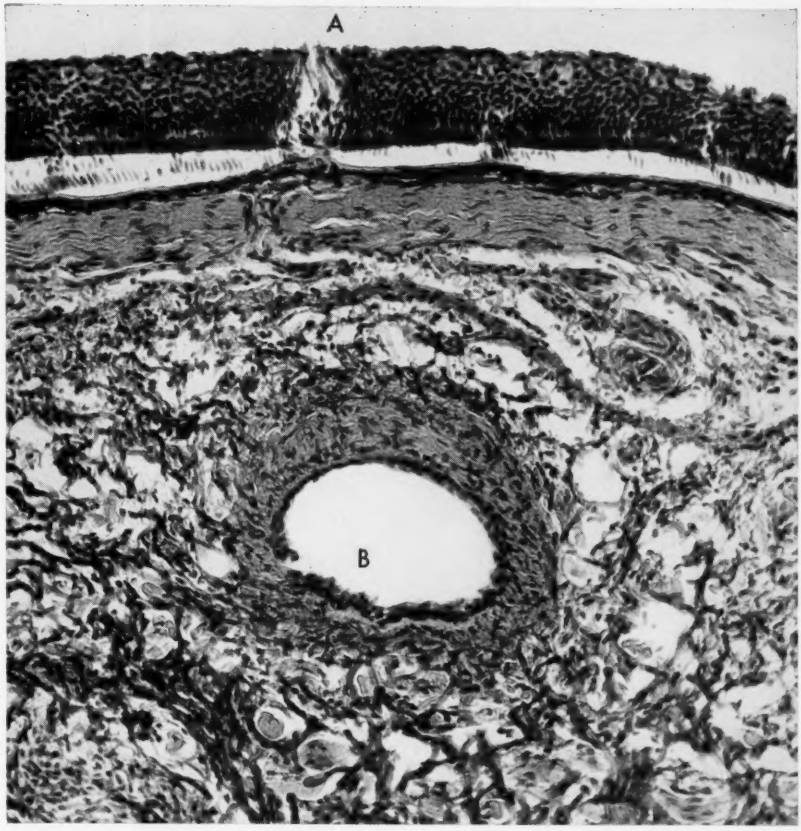



Fig. 2.—From hematoxylin-stained section of skin from the lower jaw of a common spotted moray; A—taste bud; B—lateral-line canal.

nor variation is typical for the moray's behavior during one of these tests:

Minute 0: Moray is under rocks occasionally moving head and scanning water.

Minute 1: Food introduced at far end of tank through meshes of wire screen, without touching wire or jarring.

Minute 1:30–2: Moray starts out from home searching bottom for food, moving towards other end of tank.

Minute 2–3: Moray may hit on treated or untreated food first.

Minute 3–6: If the fresh fish were encountered first, it was immediately ingested when touched with the snout, usually the lower jaw. If the moray first came upon the treated (wax covered) food, it was touched several times and then left uneaten.

Minute 6–9: Moray may return "home" and try to repeat search for food later.

In four out of seven trials, paraffin-coated anchovies were taken into the mouth and then rejected. One treated fish was swallowed, but only after the paraffin had been lacerated by the teeth and had begun to peel off.

Ingestion of food, once located by smell, therefore, seems to depend largely on taste though it is also possible that the treated food "felt" sufficiently different from untreated

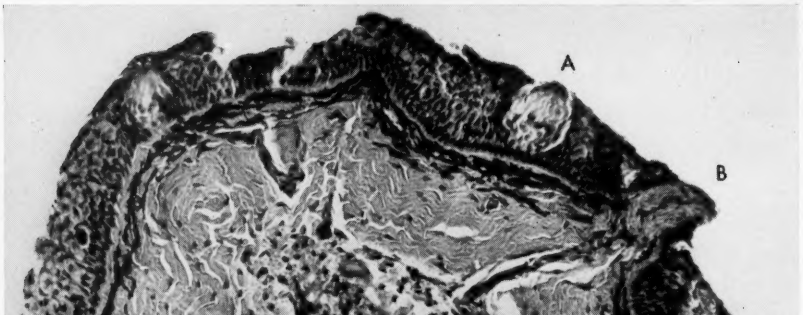



Fig. 3.—From hematoxylin-stained skin section from lower jaw of a common spotted moray; A—taste bud; B—sensory structure of unknown function, probably touch.

anchovies and that the discrimination was, in part, based on touch.

Tastebud-like structures are spread profusely over the outside of the lower jaw (Figs. 2 and 3). They not only resemble the sensory buds described from *Barbus fluviatilis* and *Ameiurus melas* (Kuekenthal, *et al.*, 1956: 843–57) but are very much like the taste buds of higher vertebrates (Maximow and Bloom, 1957:201–03). In addition there are sensory structures which appear to be composed of a heavy envelope of layered corium tissue with coiled nerve elements in the center, quite different from the onion-like structure of taste buds (Fig. 3). They resemble Meissner's corpuscles which have been reported as touch receptors (Ham, 1957:829). Eosin hematoxylin and Bodian's protargol silver staining methods both showed this similarity. A more detailed account of their histology will be published elsewhere.

It is, indeed, likely that touch plays some role in eliciting the food-grasping response once the food object has been located by smell and taste. This is also supported by the observations of Winn and Bardach (Ms.) who investigated the reactions of normal and blinded morays to the mucous envelopes of certain parrot fishes. It appeared from these experiments also as though touch played a part in the discrimination between palatable and unpalatable objects.

The lateral-line sense is the only one which did not lend itself to these relatively simple controlled observations. Concerning it, we can say that the moray eel bears a very well developed lateral-line pore system on the upper and lower jaws, such as has been described for the common eel (Wunder, *loc. cit.*). The surface sensory structures described above frequently lie very close to the pores of these lateral-line canals (Fig. 2).

All these observations and experiments suggest that the morays—at least, the two common species we observed—detect their food by smell as do many other fishes. They further indicate that taste and touch receptors become important once the food has been located and that these senses, either singly or jointly, elicit the food-grasping response.

Unfortunately, we have no experimental data on the importance of lateral-line organs in feeding. The profuse development of this sensory system on the head indicates, however, that it should contribute to feeding if live, moving food is involved. Sight is a relatively unimportant sense in these scavenging reef predators.

## Summary

Observations and activity records clearly demonstrated that the two common Atlantic moray eels, *Gymnothorax moringa* and *G. vicinus*, are nocturnally active. This rhythm

tends to persist for a time under uniform darkened conditions.

Experiments demonstrated that smell is used in the location of distant food. Once the food is approached, the moray touches it with its snout and taste stimuli elicit immediate grasping of the food. Tactile receptors possibly play a subsidiary role in the last response.

### Literature Cited


Bardach, John E. 1958. On the movements of certain Bermuda reef fishes. *Ecology 39(1): 139–46.*

———. 1959. The summer standing crop of fish on a shallow Bermuda reef. *Limnol. and Oceanogr. 4(1): 77–85.*

Browman, Ludwig G. 1952. Artificial sixteen hour day activity rhythm in the white rat. *Amer. Jour. Physiol. 168: 694–697.*

Brown, Frank A., Jr., Marguerite Webb, Miriam Bennett, and Muriel Sandeen. 1954. Temperature independence of the frequency of the endogenous tidal rhythm of *Uca*. *Physiol. Zool. 27(4): 345–349.*

Ham, Arthur W. 1957. Histology. *J. B. Lippincott & Co., Philadelphia. 866 pp.*

Hasler, Arthur D. 1954. Odour perception and orientation in fishes. *Jour. Fish. Res. Bd. Can 11(2): 107–129.*

Kuekenthal, Willy, *et al.* 1956. Handbuch der Zoologie. *Pisces, VI. erste Haefte, 9 Lieferung, pp. 843–57.*

MacGinitie, G. E., and N. MacGinitie. 1949. The natural history of marine animals. *McGraw-Hill Book Co., New York. 473 pp.*

Maximow, Alexander A., and William Bloom. 1957. A textbook of histology. *W. B. Saunders Co., Philadelphia. 628 pp.*

Winn, Howard E., and John E. Bardach. 1959. Differential food selection by moray eels and a possible role of the mucous envelope of parrot fishes in reduction of predation. *Ecology, In Press.*

Wunder, Wilhelm. 1927. Sinnesphysiologische Untersuchungen über die Nahrungsaufnahme bei verschiedenen Knochenfischenarten. *Zeitschr. Vergl. Physiol. 6(1): 67–98.*


Department of Fisheries, University of Michigan, Ann Arbor, Michigan; Department of Zoology, University of Maryland, College Park, Maryland; and Bermuda Biological Station.

# Two New Flatfishes of the Genus *Ancylopsetta* from the Guiana Coast

James C. Tyler

Among the material collected by the United States Fish and Wildlife Service vessel *Oregon* and the M/V *Coquette*, exploratory vessel of the Government of Surinam, are the two species of paralichthine flatfishes described below.

Unless otherwise stated, measurements were taken on the ocular side and were made with dividers and recorded to the nearest half millimeter. The horizontal diameter of the eye is that of the lower eye itself, not of the orbit. The length of the snout was measured from the tip of the upper jaw to the anterior edge of the lower eye. The maxillary length is the distance between its anterior crest, which can be seen and felt as a skin-covered bony protuberance on the snout, and its most posterior point. The length of the lower jaw is the distance between its anterior edge and the externally noticeable downward projection of the articular bone. The lateral-line scale count is the number of scales in the lateral line between the base of the caudal fin and a point above the upper attachment of the opercular flap. The number of scales above the lateral line is the number in an anteriorly directed oblique row beginning just behind the arch of the lateral line and ending at the dorsal fin base. The number of scales below the lateral line is the number in a posteriorly directed oblique row beginning just behind the arch of the lateral line and ending at the anal fin base. The thickness of the body is measured above the pectoral fins. The attachment of the enlarged first interhaemal spine to a vertebra marks the beginning of the caudal vertebral series and those vertebrae anterior to this attachment are designated as abdominal.

Proportional measurements discussed in the text are given in terms of the range of variation, followed in parentheses by the average value of that measurement to the nearest whole number. The average is based on the specimens listed in the table for the species under consideration.

The term "single dichotomy" refers to the branching of a single fin-ray into two seg-

TABLE 1

SELECTED COUNTS AND PROPORTIONAL MEASUREMENTS OF *Ancylopsetta cycloidea*

| | Holotype USNM 159793 | Paratypes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ANSP 82633 | SU 51069 | MCZ 39987 | USNM 159794 | USNM 159794 | USNM 159794 | USNM 159794 | USNM 159794 | USNM 159794 |
| Standard Length (mm.) | 155 | 138 | 165 | 160 | 140 | 116 | 98.5 | 96 | 90 | 88 |
| Head Length (mm.) | 45 | 39 | 47 | 45 | 40 | — | 29 | 28.5 | 27 | 26 |
| Counts | | | | | | | | | | |
| Dorsal Fin | 64 | 66 | 65 | 67 | 65 | 65 | 68 | 65 | 66 | 65 |
| Anal Fin | 49 | 51 | 49 | 52 | 49 | 52 | 52 | 51 | 51 | 49 |
| Pectoral Fin—ocular side | 10 | 11 | 10 | 10 | 10 | 10 | 11 | 10 | 10 | 11 |
| —blind side | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 11 | 9 | 10 |
| Lateral-line Scales | 70 | 72 | 72 | 76 | 76 | — | 71 | 68 | 71 | 71 |
| Scales above Lateral Line | 24 | 25 | 26 | 25 | 24 | — | 23 | 25 | 25 | 28 |
| Scales below Lateral Line | 25 | 25 | 28 | 27 | 26 | — | 23 | 25 | 25 | 26 |
| Measurements (in percent of Standard Length) | | | | | | | | | | |
| Greatest Body Depth | 45 | 47 | 45 | 45 | 48 | 47 | 48 | 47 | 49 | 49 |
| Length of Pelvic Fin | | | | | | | | | | |
| —ocular side | 39 | 45 | 28 | 33 | 41 | 34 | 43 | 38 | 48 | 46 |
| —blind side | 11 | 12 | 12 | 11 | 11 | 12 | 12 | 13 | 13 | 14 |
| Length of Longest (third) Ray of Dorsal Fin | 36 | 38 | 39 | 37 | 38 | 35 | 32 | 38 | 42 | 41 |

ments. The term "double dichotomy" refers to the condition in which each of the two segments thus formed splits into two more segments. The term "triple dichotomy" refers to the condition in which each of the four segments produced by the type of splitting described in the last sentence splits into two parts, making a total of eight terminal elements. "Incomplete triple dichotomy" is the term which refers to the condition in which some, but not all, of the four segments produced by a double-dichotomous branching split into two segments, making a total of five, six, or seven terminal elements.

Abbrevations of museum names are as follows: Stanford University Natural History Museum—SU; United States National Museum—USNM; Chicago Natural History Museum—CNHM; Academy of Natural Sciences of Philadelphia—ANSP; Museum of Comparative Zoology, Harvard University—MCZ.

**Ancylopsetta cycloidea**, *sp. nov.*

HOLOTYPE.—USNM 159793, *Oregon* Sta. 2021, 07°18′N., 53°32′W., 100 fath., Nov. 8, 1957.

PARATYPES.—One specimen, ANSP 82633, *Oregon* Sta. 2022, 07°15′N., 53°25′W., 115 fath., Nov. 9, 1957; one specimen, SU 51069, *Oregon* Sta. 2021; one specimen, MCZ 39987, *Oregon* Sta. 2021; six specimens, USNM 159794, *Oregon* Sta. 2021; one specimen (S. L. 90 mm.), CNHM 64455, *Oregon* Sta. 1987, 09°36′N., 59°44′W., 80 fath., Nov. 4, 1957; eight specimens (S. L. 152 mm. to 86 mm.) CNHM 64456. *Oregon* Sta. 2021.

*Diagnosis.—Ancylopsetta cycloidea* can be distinguished from all other known species of the genus by the cycloid scales on the ocular side and the extreme elongation of its anterior dorsal fin-rays. The length of these elongated rays is greater than the length of the head, while in no other *Ancylopsetta* are these rays as long as the head.

*Description.*—Selected counts and proportional measurements of the holotype and first nine paratypes listed above are given in Table 1.

Body elliptical (Fig. 1), its greatest depth nearly one half the standard length. Head tapering irregularly to a blunt snout, in length 28 to 30 (29) percent of standard length. Length of the stout lower jaw 52 to 57 (55) percent of head length. Upper jaw shorter, its length about 48 percent of head length. Maxillary length 45 to 48 (47) percent of head length. Diameter of eye 26 to 31 (29) percent of head length. Length of snout 20 to 21

(20) percent of head length. Distance between tip of snout and most posterior point of preoperculum 76 to 81 (78) percent of head length. Thickness of body 8 to 10 (9) percent of standard length. All 19 specimens with ten abdominal vertebrae. Caudal vertebrae 24 in three specimens, 25 in 16 specimens. Typically three gillrakers on upper arm and seven on lower arm of first gill arch. Six branchiostegals present on each side. Pseudobranchiae well developed.

Jaws with sharp, conical teeth which increase in size anteriorly, and which are equally developed on both sides in a single row. Largest teeth shorter than interorbital width. No teeth on vomer or palatines. Teeth similar to those of jaws present in several bands on dorsal pharyngeals and in small patch on ventral pharyngeals.

Nostrils close together; distance between centers of anterior and posterior nostrils on same side being about equal to interorbital width. Nostrils on ocular side are just anterior to upper anterior edge of orbit of lower eye. Those on blind side are above and behind expanded anterior edge of maxillary. A dermal flap present at posterior edge of anterior nostrils on both sides. Nasal organs with about ten laminae on each side of a central rod, laminae becoming somewhat smaller toward distal end of rod.

Both sides of body uniformly covered with cycloid scales. Snout, interorbital area, and upper and lower jaws naked. Scales more deeply imbedded than in any other species of *Ancylopsetta*. Dorsal, anal, and caudal fins on ocular side have scales extending nearly to their tips on skin overlying fin-rays, but not on interradial membranes. These fins similarly scaled on blind side, but scales more deeply imbedded. Basal portions of pelvic fins scaled on their lateral surfaces. Pectoral fins naked. Lateral-line scales oblong and continuing a short distance onto caudal fin. Tubes from lateral-line canals usually run a short distance postero-dorsally but often postero-ventrally; occasionally a tube extends in both directions. Tubes of sensory canal system on head are longer and more branched than those of lateral line. Their

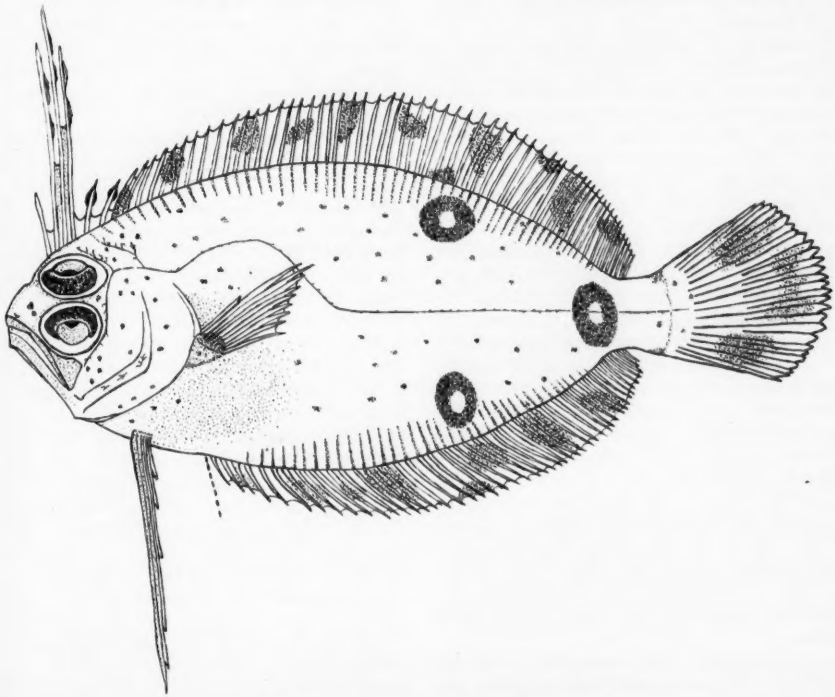


Fig. 1.—*Ancylopsetta cycloidea*, holotype

usual placement shown in Figure 1. Lateral line on blind side similar to that on ocular side. Rays of pectoral and pelvic fins unbranched. Length of pectoral fin on ocular side 18 to 20 (19) percent of standard length. Pectoral fin on blind side slightly shorter, 16 to 19 (18) percent of standard length. All specimens with six pelvic fin rays on both sides, except one specimen with only five on ocular side. See Table 1 for number of pectoral, dorsal, and anal fin rays. Dorsal and anal fin-rays unbranched, except for about last 12, which distally are branched in single dichotomies. Longest ray of dorsal fin is the third, while longest pelvic fin-ray is the first. See Table 1 for their lengths. Caudal fin with 17 rays, the most dorsal two and most ventral two usually unbranched. The remaining 13 typically branched in double or incomplete triple dichotomies. Caudal fin length 21 to 26 (24) percent of standard length. Length of caudal peduncle 6 to 7 (7) percent of standard length, its depth 10 to 11 (11) percent of standard length.

Vent asymmetrically placed just in front of anal fin origin and somewhat to blind side of the mid-line.

Color of ocular side of recently preserved material light tan. Abdominal region darker. Small, solid, dark-tan spots scattered irregularly over body and head. Three large ocelli on body (Fig. 1). Creamy colored center of each ocellus surrounded by a wide circle of dark tan, which itself is surrounded by a very narrow creamy circle. Dorsal, anal, and caudal fins creamy in color, with dark tan blotches irregularly placed on this creamy background. Anterior portion of left pelvic fin dark tan, while posterior portion is pale. Pectoral fin pale, except for a dark tan spot at base. An oily, orange-red substance, just beneath skin, forms bands which are more or less vertical to body edge, over fin-ray musculature to fin-ray bases. A faint tan band marks the end of caudal peduncle. Color on blind side uniformly creamy, with exception of dark blotches on dorsal, anal, and caudal fins and of orange-red bars of same type and relative position as occur on ocular side. Darkish tan coloration of skin covering premaxillary on ocular side extends over slightly to skin covering premaxillary on blind side. Anterior edge of right pelvic fin dark, while rest of fin is pale.

*Relationships.*—The completely cycloid scales of this new species lends further evidence to the presumed close relationship of *Ancylopsetta* and *Gastropsetta*. These two genera are usually differentiated by the position of the dorsal fin origin and the type of scales. *Gastropsetta* has the dorsal fin origin anterior to the front edge of the upper eye, while in *Ancylopsetta* the origin is just above or slightly posterior to the edge of the upper eye. *Gastropsetta* possesses entirely cycloid scales, while that of *Ancylopsetta* is said to be exclusively ctenoid (Norman, 1934). On the basis of these two characters, *A. cycloidea* is intermediate between the two genera, for its dorsal fin origin is characteristic of *Ancylopsetta* and its scales of *Gastropsetta*. Equally noteworthy is the fact that *G. frontalis* (Bean, 1895:633–4), the only species of this genus, and *A. cycloidea* are not unique in the possession of cycloid scales, for such are also found on the blind side of *A. dilecta* (Goode and Bean, 1883:192–4; Jordan, 1885:134). Some ctenoid scales occur near the lateral line and peripheral body areas on the blind side of *A. dilecta*. Many specimens from the South Atlantic states and Gulf coasts have been checked for this character on the blind side, and in none were the cycloid scales outnumbered by ctenoid. The extent to which the scales are imbedded in *A. cycloidea* is less than in *G. frontalis* and more than in the other species of *Ancylopsetta*, thus showing another intermediate character.

Several superficial characters, besides the cycloid scales, suggest a possible relationship between this new species and *Gastropsetta*. One of these is the extensive elongation of the anterior rays of the dorsal fin and left pelvic fin. These rays are longer than those of the other species of *Ancylopsetta*, and about the same length as those of *G. frontalis*. Another character common to *A. cycloidea* and *G. frontalis* is the presence of dermal flaps on the distal portions of the elongated dorsal fin-rays, although these flaps are absent from the elongated rays of the left pelvic fin of *A. cycloidea* and present in *G. frontalis*.

Within the genus *Ancylopsetta* the new species may be most closely related to *A. dilecta*, which possesses some cycloid scales on the blind side and has dermal flaps on a few of the anterior dorsal fin-rays. Its anterior dorsal fin-rays are about twice as long as the succeeding fin-rays. These fin-rays in *A. cycloidea* are also elongated, though much more so than in *A. dilecta*. *A. quadrocellata* (Gill, 1864:224) is the only other species of the genus which has these fin-rays elongated. It differs, however, from *A. cycloidea* and *A. dilecta* in its lack of any cycloid scales, other

TABLE 2

SELECTED COUNTS AND PROPORTIONAL MEASUREMENTS OF *Ancylopsetta kumperae*

| | Holotype USNM 159623 | Paratypes USNM 159622 | USNM 159620 | SU 51074 | USNM 159466 | USNM 159466 | USNM 159507 | ANSP 83387 | USNM 159472 | USNM 159472 | USNM 159728 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Standard Length (mm.) | 183 | 173 | 172 | 154 | 89.5 | 89 | 84.5 | 84 | 75.5 | 74 | 81 |
| Head Length (mm.) | 51 | 44 | 45 | 43 | 25 | 25.5 | 24 | 23.5 | 22 | 21 | 23 |
| Counts | | | | | | | | | | | |
| Dorsal Fin | 78 | 79 | 77 | 76 | 80 | 84 | 82 | 79 | 76 | 77 | 80 |
| Anal Fin | 58 | 60 | 59 | 59 | 61 | 61 | 63 | 63 | 60 | 61 | 60 |
| Lateral-line Scales | 87 | 94 | 92 | 91 | 99 | 89 | 95 | 93 | 87 | 81 | 93 |
| Scales above Lateral Line | 38 | 33 | 33 | 35 | 36 | 30 | 33 | 35 | 35 | 32 | 36 |
| Scales below Lateral Line | 43 | 38 | 41 | 37 | 39 | 36 | 38 | 38 | 39 | 35 | 37 |
| Measurements (in percent of Standard Length) | | | | | | | | | | | |
| Greatest Body Depth | 55 | 53 | 52 | 54 | 50 | 50 | 49 | 49 | 50 | 49 | 49 |
| Length of Pelvic Fin | | | | | | | | | | | |
| —ocular side | 18 | 16 | 17 | 16 | 17 | 18 | 17 | 15 | 17 | 16 | — |
| —blind side | 13 | 12 | 11 | 12 | 13 | 10 | 11 | 13 | 13 | 14 | 14 |

than those in its lateral line, in the relative shortness of the left pelvic fin, and in the presence of four, rather than three, ocelli on the body. The left pelvic fin of *A. dilecta* is more than twice as long as the pelvic fin on the blind side, though even this extensive elongation is not equal to the extreme elongation of the left pelvic fin of *A. cycloidea*. The only other species of the genus with a very long left pelvic fin is *A. dendritica* (Gilbert, 1891:121–2). This species differs from *A. dilecta* and *A. cycloidea* in its greater number of vertebrae, in its shorter anterior dorsal fin-rays and in its relatively wide interorbital area. The general shape of the body of *A. dilecta* is similar to that of *A. cycloidea*. Both possess only three ocelli and normally have seven gillrakers on the lower limb of the first arch. The number of vertebrae in the caudal series and the number of dorsal and anal fin-rays are less in *A. cycloidea* than in *A. dilecta*. The species is named *cycloidea* in reference to its cycloid scales.

**Ancylopsetta kumperae**, *sp. nov.*

HOLOTYPE.—USNM 159623, *Coquette* Sta. 297,06°45′N., 55°17′W., 24 fath., June 28, 1957.

PARATYPES.—One specimen, USNM 159622, *Oregon* Sta. 2036, 06°13′N., 52°53′W., 30 fath., Nov. 11, 1957; one specimen, USNM 159620, *Oregon* Sta. 2050, 04°04′N., 50°32′W., 40 fath., Nov. 13, 1957; one specimen, SU 51074, *Coquette* Sta. 29, 06°49′N., 55°54′W., 26 fath., May 12, 1957; two specimens, USNM 159466, *Coquette* Sta. 267, 06°42′N., 55° 43′W., 24 fath., June 20, 1957; one specimen, USNM 159507, *Coquette* collections off Surinam, no precise data; one specimen, ANSP 83387, *Coquette* Sta. 274, 06°41′N., 55°27′W., 23 fath., June 25, 1957; two specimens, USNM 159472, *Coquette* Sta. 297, 06°45′N., 55°17′W., 24 fath., June 28, 1957; one specimen, USNM 159728, *Coquette* Sta. 260, 06°41′N., 55°26′W., 23 fath., June 20, 1957; one specimen (S. L. 180 mm.) CNHM 64454, *Oregon* Sta. 2051, 04°05′N., 50°27′W., 50 fath., Nov. 13, 1957; one specimen (S. L. 169 mm.), CNHM 64453, *Oregon* Sta. 2017, 07°12′N., 54°08′W., 40 fath., Nov. 8, 1957.

*Diagnosis.—Ancylopsetta kumperae* differs from all other members of its genus by the extensive branching of the pelvic fin-rays on the ocular side, particularly that of the last two rays. These last two rays are typically split in incomplete triple dichotomies, while in the other species of this genus these rays form no more than single dichotomies. The dark centers of the ocelli also distinguish *A. kumperae* from the other species of the genus, all of which have pale centers in the ocelli.

*Description.*—Selected counts and proportional measurements of the holotype and first ten paratypes listed above are given in Table 2.

Body broadly elliptical, its greatest depth

being somewhat more than half the standard length. Head tapering irregularly to a blunt snout, in length 24 to 29 (28) percent of standard length. Length of stout lower jaw 51 to 55 (53) percent of head length, upper jaw slightly shorter. Maxillary length 41 to 45 (43) percent of head length. Diameter of eye 20 to 26 (24) percent of head length. Length of snout 16 to 20 (18) percent of head length. Distance between tip of snout and most posterior point of preoperculum 71 to 75 (73) percent of head length. Thickness of body 7 to 9 (8) percent of standard length. All 13 specimens with ten abdominal vertebrae. Caudal vertebrae 25 in one specimen, 26 in nine specimens, 27 in three specimens. Typically two gillrakers on upper arm and six or seven on lower arm of first gill arch.

The dentition, nostrils, lateral line, position of the vent, pseudobranchiae, and branchiostegals are essentially the same as those of *A. cycloidea*.

Both sides of body completely covered with ctenoid scales, as is skin over rays of dorsal, anal, caudal, and pelvic fins. Pectoral fins naked. Interorbital and postocular areas covered with ctenoid scales. On both blind and ocular sides, the snout, premaxillary, and lower jaw are naked, as is maxillary on blind side. Maxillary on ocular side with about ten ctenoid scales on its expanded posterior end. Scales on dorsal, anal, caudal, and pectoral fins in same arrangement as those of *A. cycloidea*. Basal portions of pelvic fins scaled on lateral surfaces, but less so over posterior rays than over anterior rays.

Pectoral fin on blind side with 11 or 12 rays, all unbranched. Pectoral fin on ocular side with 11 or 12 rays, first two rays and last ray unbranched, the others branched in single dichotomies. Length of pectoral fin on ocular side 14 to 16 (15) percent of standard length. Pectoral fin on blind side shorter, its length 12 to 14 (13) percent of standard length. Six pelvic fin-rays on both sides in all specimens. Pelvic fin on ocular side normally with first ray unbranched, and second, third, and fourth rays branched in single dichotomies. Fifth and sixth rays branched in incomplete triple dichotomies, with first dichotomous branching being quite close to base of rays. Pelvic fin on blind side only slightly shorter than its mate on ocular side. Its rays less branched than those of pelvic fin on ocular side, usually with first two rays unbranched, next two rays branched in single dichotomies, and last two rays branched in double dichotomies. Anterior rays of dorsal fin not longer than succeeding rays. Approximately first 30 rays of dorsal and anal fins unbranched, remaining rays branched in single dichotomies, except for last few rays at

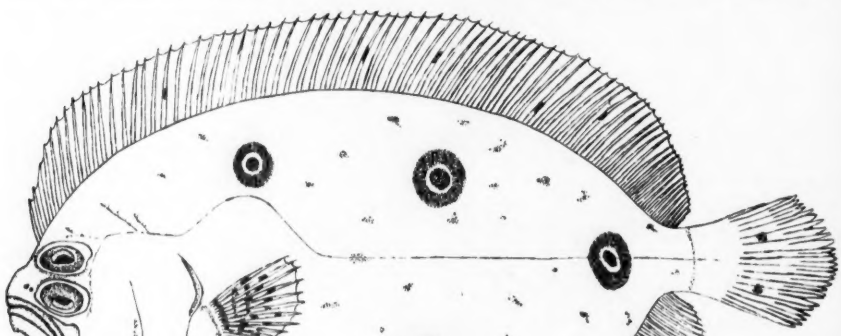


Fig. 2.—*Ancylopsetta kumperae*, holotype

TABLE 3

COMPARATIVE DATA FROM FIN-RAY COUNTS OF *Ancylopsetta* AND *Gastropsetta*

Dorsal Fin-Rays

| | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. cycloidea* | | | | | | 2 | 3 | 7 | 3 | 3 | 1 | | | | | | | | | | | | | | | | |
| *A. dilecta* | | | | | | | | | | | | 3 | 4 | 6 | 10 | 4 | 4 | 4 | 3 | 1 | 3 | | | | | | |
| *A. kumperae* | | | | | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 1 | 1 | — | 1 |
| *A. quadrocellata* | | | | | | | | 2 | 1 | 2 | — | 1 | 3 | 3 | 3 | 2 | 3 | 1 | 2 | 1 | | | | | | | |
| *A. dendritica* | | | | | | | | | | | | | | | | | | | 1 | — | — | 1 | — | 1 | — | 1 | 1 |
| *G. frontalis* | 1 | — | 1 | 1 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | |

Anal Fin-Rays

| | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *A. cycloidea* | | | 2 | 5 | 4 | 5 | 3 | | | | | | | | | | | | | | | |
| *A. dilecta* | | | | | | | | 3 | 5 | 8 | 4 | 6 | 6 | 4 | 4 | 2 | | | | | | |
| *A. kumperae* | | | | | | | | | | | | | 1 | 2 | 3 | 5 | — | 2 | | | | |
| *A. quadrocellata* | | | | | | | 2 | 2 | 2 | 5 | 2 | 3 | 3 | 5 | | | | | | | | |
| *A. dendritca* | | | | | | | | | | | | | | | | | | 3 | — | 1 | — | 1 |
| *G. frontalis* | | 1 | — | 1 | — | 4 | — | — | 1 | | | | | | | | | | | | | |

end of fins which are branched in double dichotomies. See Table 2 for number of dorsal and anal fin-rays. Caudal fin with 17 rays, branched in same manner as those of *A. cycloidea*. Caudal fin length 18 to 23 (21) percent of standard length. Length of caudal peduncle about four percent of standard length, depth about 11 percent of standard length.

Color on ocular side of bodies of recently preserved material brownish to tan, with abdominal region darker. Four large ocelli as well as dark, irregularly scattered blotches on body. Center of each ocellus dark brown, this surrounded by a pale tan circle, which likewise is surrounded by a dark brown band. A narrow, creamy colored area encircles this outer dark brown band in most specimens. Dorsal, anal, and caudal fins color of body, with occasional blotches of darker brown. Left pelvic fin also color of body, but skin between more anterior pelvic fin-rays is dark in some specimens. A dark brown to blackish spot, encircled by a creamy band, lies between and partially over distal portions of third and fourth fin-rays of pelvic fin on ocular side. In several specimens the oily, orange-red bars, as described under *A. cycloidea*, are visible, but in most specimens there is no external evidence of them. Skin covering premaxillary and upper region of lower jaw darker than that of rest of head. A faint brown band marks the end of caudal peduncle. Blind side generally creamy in color. However, small spots of grayish tan present on snout. Dorsal, anal, and caudal fins as tan in color on blind side as they are on ocular side. The orange-red bars are evident in several specimens on blind side, but in most they are not visible. Skin overlying fin-ray musculature on blind side, particularly in smaller specimens, finely spotted with tan, giving this area a dusky appearance.

*Relationships.*—At first glance this new species may be mistaken for *A. quadrocellata*. Both species possess a similar body shape, ocelli in similar positions, and relatively short pelvic fins. The anterior dorsal fin-rays of *A. quadrocellata* are somewhat, but not excessively, elongated. This is in contrast to *A. kumperae*, in which these rays are not at all longer than the succeeding rays. *Ancylopsetta dendritica* is the only other species of the genus in which these fin-rays are not elongated. The latter species differs, however, in several important characters from both *A. kumperae* and *A. quadrocellata*: Its pelvic fin on the ocular side is moderately elongated, its interorbital area is wider, and it has more vertebrae.

*Ancylopsetta kumperae* and *A. quadrocellata* have only ctenoid scales. The number of vertebrae is the same in the two species, although the dorsal and anal fin-rays are more numerous in *A. kumperae*. This latter species possesses the same characters which have been

mentioned in setting apart *A. quadrocellata* from the other species of the genus. This, taken in conjunction with the facts just presented concerning *A. kumperae* and *A. quadrocellata,* shows that these two species are more closely related to each other than to any other species in the genus.

The species is named in honor of Miss Helga O. Kumpera.

### Differentiation of *Ancylopsetta* from *Gastropsetta*

The new species have been compared with the single species of *Gastropsetta* and with the three previously described species of *Ancylopsetta.* One external character, the form of the head anterior to the eyes, consistently separates the two genera. The forward position of the origin of the dorsal fin in *G. frontalis* has brought a mass of muscle and bony material to the region immediately in front of the anterior edge of the upper eye orbit. This material gives the profile of the head above the eyes an even, convex curve. There is no such mass of material in *Ancylopsetta* and the anterior edge of the orbit of the upper eye helps form the profile of the head in this region. Due to the lack of this tissue mass, the generally convex profile of the head above the mouth is broken by a slight to moderate concavity anterior to the upper eye. This concavity is quite distinct in *A. dilecta* and *A. quadrocellata,* as well as in both of the new species. It is less distinct, but still discernible, in *A. dendritica.*

Table 4

Comparative Data from Vertebral Counts of *Ancylopsetta* and *Gastropsetta*

| | 10–24 | 10–25 | 10–26 | 10–27 | 10–28 | 11–28 |
|---|---|---|---|---|---|---|
| *A. cycloidea* | 3 | 16 | | | | |
| *A. dilecta* | | | 11 | 11 | | |
| *A. kumperae* | | 1 | 9 | 3 | | |
| *A. quadrocellata* | | 2 | 14 | | | |
| *A. dendritica* | | | | | | 5 |
| *G. frontalis* | | | | 6 | 1 | |

The head regions of several specimens of each of the species under consideration were dissected and a larger number were X-rayed. No significant differences between the genera were noticed in the skull itself or in the vertebral column. However, *A. dendritica,* the Pacific species of this genus, can be separated from the Atlantic species by its greater number of vertebrae, particularly those of the abdominal series (Table 4).

The dentition in both genera is similar, the teeth being sharp and conical. They increase in size anteriorly and are about equally developed in a single row on both sides of the jaws. The following characters are likewise common to both genera: sharp conical teeth in several bands on the dorsal pharyngeals and a small patch on the ventral pharyngeals; rather large "teeth," mostly covered by membranes, on the posterior edge of the gill-rakers; well developed pseudobranchiae and six branchiostegals on each side.

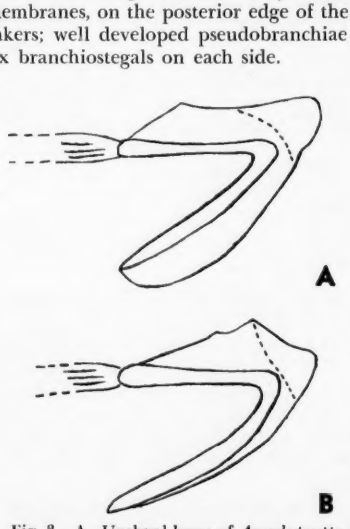



Fig. 3.—A—Urohyal bone of *Ancylopsetta cycloidea,* which is typical of the species of *Ancylopsetta.* B—Urohyal bone of *Gastropsetta frontalis.* The anterior end is at the left.

An osteological character which clearly separates the genera is the structure of the urohyal (Fig. 3). When the operculum is lifted forward a single medial notch is visible in the lower anterior profile of the shoulder girdle. This notch is bordered above and below by the V- or boomerang-shaped urohyal. The upper arm of this bone is horizontal and the bend is posteriorly directed. The lower arm runs antero-ventrally. The bone is attached anteriorly to a large ligament which runs forward to the basihyal region. When the muscles are carefully detached and laid back from the visible edge of the urohyal, it can be observed that the inner edge of the bone is stout and somewhat rounded. Projecting dorsally from the horizontal arm of the bone is a keel several times the breadth of the rounded, stout shaft. The difference between the genera concerns the keel on the

antero-ventrally directed arm of the urohyal. The species of *Ancylopsetta* have the keel in this region well developed. On the lower half of this arm it is two or three times as wide as the diameter of the shaft from which it projects. In *Gastropsetta* the keel on this lower arm is only poorly developed. On the lower half of this arm it is not broader than the shaft from which it projects.

It seems evident that the previously described species of *Ancylopsetta* and the two species here placed within the genus can be differentiated from *G. frontalis* by the presence in *Ancylopsetta* of the following characters: the ventral arm of the urohyal with a well developed keel, in contrast to the poorly developed keel of *Gastropsetta*; the dorsal fin origin just above or slightly posterior to the anterior edge of the upper eye, in contrast to the more anterior dorsal fin origin of *Gastropsetta*; and a concavity anterior to the front of the upper eye orbit, in contrast to the convex profile of *Gastropsetta*.

### Distribution of *Ancylopsetta* and *Gastropsetta*

*G. frontalis:* Atlantic Ocean and Gulf of Mexico from Yucatan, Mexico, to North Carolina, 25 to 38 fath. *A. quadrocellata:* Atlantic Ocean and Gulf of Mexico from Campeche, Mexico, to North Carolina, 2 to 80 fath., usually between 10 and 20 fath. *A. dilecta:* Atlantic Ocean and Gulf of Mexico from Texas to North Carolina, 40 to 112 fath. Hsiao (1940:195) reports a postlarval specimen from Georges Bank (off New England). *A. dendritica:* Pacific Ocean from Panama north into the Gulf of California, about 10 fath. *A. cycloidea:* Atlantic Ocean from French Guiana to British Guiana, 80 to 115 fath. *A. kumperae:* Atlantic Ocean from the northernmost coast of Brazil to Surinam, 23 to 50 fath.

### Key to the Species of *Ancylopsetta* and *Gastropsetta*

1*a*. Dorsal fin beginning anterior to anterior edge of upper eye; keel on ventrally directed portion of V-shaped urohyal poorly developed, its breadth on most ventral half of ventrally directed portion less than breadth of the shaft from which it projects; profile of head above the mouth an even convex curve (Genus *Gastropsetta*) . . . *Gastropsetta frontalis.*

1*b*. Dorsal fin beginning posterior to or just above anterior edge of upper eye; keel on ventrally directed portion of V-shaped urohyal well developed, its breadth on most ventral half of ventrally directed portion several times that of the shaft from which it projects; the generally convex profile of the head above the mouth with a slight to moderate concavity in front of upper eye (Genus *Ancylopsetta*).

2*a*. Interorbital width at least half the horizontal diameter of eye; abdominal vertebrae 11 (Pacific species) . . . . . *Ancylopsetta dentritica.*

2*b*. Interorbital width a third, or less, of the horizontal diameter of eye; abdominal vertebrae 10 (Atlantic species).

3*a*. Scales on ocular side ctenoid; longest dorsal fin-ray about four-fifths, or less, of length of head.

4*a*. Interorbital area scaled; pelvic fin on ocular side elongated but not more than twice as long as pelvic fin on blind side; four dark, large, ocelli on body.

5*a*. Proximal portions of last two pelvic fin-rays on ocular side no more branched than preceding rays, the last two rays usually split in single dichotomies; ocelli with light centers; some of anterior-most five or six rays of dorsal fin longer, by about a third, than succeeding five or six rays *Ancylopsetta quadrocellata.*

5*b*. Proximal portions of last two pelvic fin-rays on ocular side considerably more branched than preceding rays, the last two rays usually split in incomplete triple dichotomies; ocelli with dark centers; none of anterior-most five or six rays of dorsal fin appreciably longer than succeeding five or six rays . . . . . *Ancylopsetta kumperae.*

4*b*. Interorbital area naked; pelvic fin on ocular side more than twice as long as that on blind side; three dark, large

ocelli on body.....
.....*Ancylopsetta dilecta*

3*b*. Scales on ocular side cycloid; longest dorsal fin-ray equal to or greater than length of head....
.....*Ancylopsetta cycloidea*

ACKNOWLEDGMENTS

I wish to express my thanks to Dr. Giles W. Mead, U. S. Fish and Wildlife Service, for making specimens available to me and for his helpful comments on the manuscript. I am also indebted to Loren P. Woods, Chicago Natural History Museum, for the loan of specimens and for color photographs of fresh *A. kumperae,* and to Dr. Ernest Lachner, U. S. National Museum, and Dr. George S. Myers, Stanford University, for their suggestions on the manuscript.

LITERATURE CITED

BEAN, BARTON A. 1895. Scientific results of the U. S. Fish Commission Steamer *Albatross,* XXXIII—Descriptions of two new flounders, *Gastropsetta frontalis* and *Cyclopsetta chittendeni. Proc. U. S. Nat. Mus. 17: 633–6.*

GILBERT, CHARLES H. 1891. Scientific results of explorations by steamer *Albatross,* XII—Preliminary report on the fishes collected by the steamer *Albatross* on the Pacific coast of North America during the year 1889, with descriptions of twelve new genera and ninety-two new species. *Proc. U. S. Nat. Mus. 13: 49–126.*

GILL, THEODORE N. 1864. Descriptions of new genera and species of eastern American Pleuronectoids. *Proc. Acad. Nat. Sci. Philadelphia 16: 220–4.*

GOODE, GEORGE BROWN, AND TARLETON H. BEAN. 1883. Reports on the results of dredging, under the supervision of Alexander Agassiz, on the east coast of the United States, during the summer of 1880, by the U. S. Coast Survey steamer *Blake,* XIX—Report on the fishes. *Bull. Mus. Comp. Zool., Harvard College 10*(5): *183–226.*

HSIAO, SIDNEY C. T. 1940. A new record of two flounders, *Etropus crossotus* Goode and Bean and *Ancylopsetta dilecta* (Goode and Bean), with notes on postlarval characters. *Copeia 1940*(3): *195–8.*

JORDAN, DAVID STARR. 1885. A catalogue of the fishes known to inhabit the waters of North America, north of the tropic of Cancer, with notes on the species discovered in 1883 and 1884. *Ann. Rept. Comm. Fish and Fish. for 1884: 1–185.*

NORMAN, JOHN R. 1934. A systematic monograph of the flatfishes (Heterosomata), Vol. 1—Psettodidae, Bothidae, Pleuronectidae. *British Museum (N. H.), London: viii + 459 pp., 317 figs.*

NATURAL HISTORY MUSEUM, STANFORD UNIVERSITY, CALIFORNIA, AND UNITED STATES FISH AND WILDLIFE SERVICE, WASHINGTON 25, D. C.

# A Remarkable New Genus of Anostomin Characid Fishes from the Upper Rio Xingú in Central Brazil

GEORGE SPRAGUE MYERS AND ANTENOR LEITÃO DE CARVALHO

WHEN the senior author visited Brazil in 1950, his old friend and travelling companion, Mr. Carvalho, had recently returned to Rio de Janeiro from an expedition to the headwaters of the Rio Xingú. There, amongst other things, he had collected a strange characid which he had already recognized as related to *Gnathodolus,* an even more remarkable fish from Venezuelan Guayana. My revisional paper on the anostomins had just appeared, and Carvalho and I immediately prepared a description of the new fish. Later, Carvalho drew the illustrations and sent them to me.

**Sartor,** *gen. nov.*

A genus of anostomin Characidae related to *Gnathodolus* Myers (1927) and *Synaptolaemus* Myers and Fernandez-Yepes (*in* Myers, 1950). Caudal fin scaled only basally, the distal scales large and irregular. Mouth superior, as in *Anostomus, Synaptolaemus* and *Gnathodolus,* but whereas in these three genera the closed lower jaw lies in a vertical position, in *Sartor* the lower jaw is inclined upward *and backward,* and rests at an angle of about 45 degrees from the vertical when the mouth is completely closed. In the position of the mouth, *Sartor* is thus even more specialized and peculiar than *Gnathodolus.* Lower jaw (the bony structure, without the teeth) long and narrow, about 5 times as long as broad, with the rami appressed throughout most of their length. Snout rounded in cross-section (midway between mouth and eye), much less deepened than in *Gnathodolus.* Although the

character is less strikingly developed than in *Gnathodolus,* the anterior rim of the eye is raised and the fish can undoubtedly see backward somewhat better than forward. Eye set even lower in the head than in the related genera; the eye is entirely below the level of the nostrils. Isthmus (distance between gill openings below) much narrower than in *Synaptolaemus,* about the same breadth as in *Gnathodolus.* Nostrils widely separated, even more so than in *Synaptolaemus,* the anterior tubular. General body form much like that in *Synaptolaemus,* but the head somewhat heavier and the predorsum less convex.

Teeth of lower jaw 6 in number, 3 on each side. The symphysial pair are close together, somewhat curved, greatly enlarged and elongated, and projecting straight out from the end of the jaw (as in *Gnathodolus*); they extend far above the lip of the upper jaw (outside the mouth) when the mouth is closed. In form each of these two symphysial teeth greatly resembles an awl or heavy curved needle with a lightly flattened end; together, they remind one slightly of rather slender lower rodent incisors. The posterior surface of each tooth is somewhat concave in cross section, the anterior surface strongly convex. In lateral view these two teeth are recurved. The tips are rather flattened, but are narrowly rounded when viewed from the front. The two posterior teeth on each side of the lower jaw are much smaller, the posterior one smallest; they are arranged in tandem order following the enlarged symphysial tooth. They are flattened and knife-like, and incline forward (as in *Synaptolaemus*), with the cutting edge parallel with the jaw ramus. The last tooth bears a small posterior cusp. (In the illustration, these two teeth are drawn as seen when the mouth of the formol-fixed type was forced open. The 2 posterior teeth are actually more procumbent than shown.)

Teeth of upper jaw 8, 4 on each side. They are intermediate in position and form between those of *Gnathodolus* and *Synaptolaemus,* each with a posterior cusp. My notes say that the posteriormost tooth is tricuspid, but Mr. Carvalho's figure shows only two cusps.

The figures of the dentition, head, and whole fish were prepared in the same style as (and for direct comparison with) those given by Myers (1950:188).

Upper lip plicate, wider than in related genera; the peculiar form of the mouth makes this heavy plicate lip encroach relatively far back on the dorsal surface of the head. Lower jaw with a thickly papillose lip, as in *Gnathodolus* and, to a lesser extent, in *Synaptolaemus.*

The following species is the generic type.

**Sartor respectus,** *sp. nov.*

The holotype and only known example, 83 mm. in standard length, is in the Museu Nacional, Rio de Janeiro. It was collected by the junior author in June, 1950, at Jacaré, on the Rio Kuluene (Culuene), about 40 kilometers above its mouth (its junction with the Rio Tamitatoala, which forms the Rio Xingú). Jacaré lies at approximately 12 degrees South Latitude, in the State of Matto

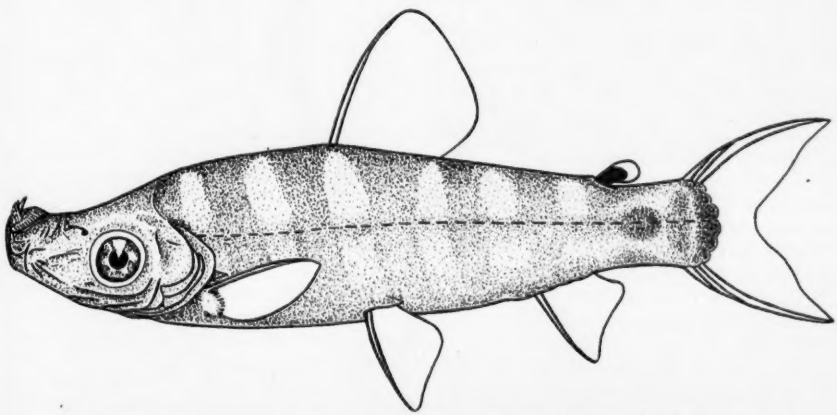


Fig. 1.—*Sartor respectus* Myers and Carvalho. Holotype. Standard length 83 mm.

Grosso, Brazil. It is (or was) an encampment of the *Fundação Brasil Central*, and is shown on plate 117 of the *Times Atlas of the World, vol. 5*, 1957, although not present on earlier maps. The Kuluene drains the northern slopes of the Serra do Roncador, which forms part of the Planalto of Matto Grosso.

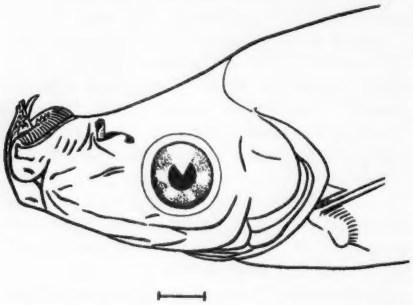


Fig. 2.—*Sartor respectus* Myers and Carvalho. Holotype. Enlarged side view of head; mouth not fully closed. The line below indicates width of isthmus, on same scale as head.

Dorsal fin 11, anal fin 10, last ray of each split almost to base. Pelvics 9. Pectorals 16. Caudal with 10 principal rays in upper half, 8 in lower half, the first and last forming tips of lobes. Lateral line complete, 38 + 3 or 4. Scales around caudal peduncle 12. Scales from dorsal origin to pelvic origin 4/1/4.

Body moderately elongate, somewhat compressed, greatest depth 3.95 in standard length. Head 3.86 in same, its lower profile convex, its upper profile concave. Middle of dorsal fin base approximately at middle of standard length. Pelvic origin slightly behind dorsal origin. Pectorals not reaching pelvics. Caudal fin symmetrically forked.

*Measurements of holotype in millimeters.*— Total length to end of scales of caudal fin 87. Standard length (middle of upper jaw to end hypural fan) 83. Head length (middle of upper jaw to end of bony opercle) 21.5. Bony orbit 6. Bony interorbital 10. Middle upper jaw to eye 8.5. Same to dorsal origin 37. Same to pelvic origin 43. Same to origin anal fin 63. Greatest body depth 21. Greatest depth caudal peduncle 10. Greatest body thickness (at opercles) 12. Length pectoral fin 15. Length pelvic fin 15. Longest anal ray (second) 10.

Color in alcohol (formol-fixed) dark brown, scales edges somewhat darker. Base of caudal darker. Traces of broad, dark oblique bands, with rather broad lighter interspaces, the bands clearly evident only dorsally, as in *Gnathodolus*. A faint, darker, mid-side blotch

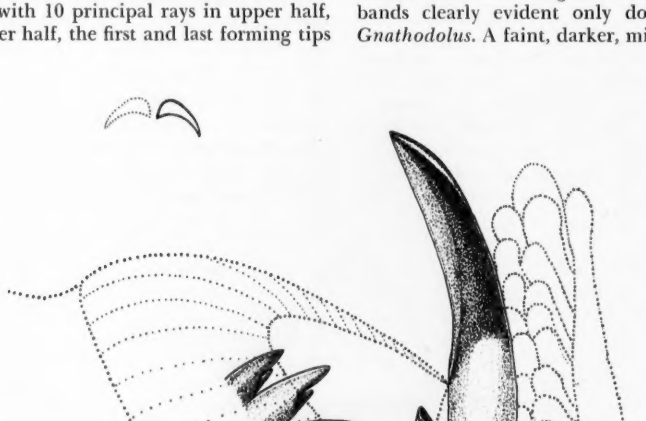


Fig. 3.—*Sartor respectus* Myers and Carvalho. Holotype. Teeth of right premaxillary (left) and right dentary (right). Dotted lines indicate plicate upper lip (left) and papillose lower lip (right). Figures at upper left represent cross-sections of enlarged symphysial teeth of dentary.

on caudal peduncle just posterior to base of adipose fin. Adipose fin basally blackish, terminally light. All other fins pale and translucent, without markings.

*Sartor* (Latin), tailor or mender, who works with a needle, in a perhaps fanciful allusion to the long, awl-like mandibular teeth. In Classical Latin, *Sartor* is a syncopated version of *Sarritor*, one who uses a hoe, and this meaning could perhaps be applied to the present fish; *Sarritor* is already used in Ichthyology. *Respectus* (Latin), looking backward or about, in reference to the eye position.

## Comparisons and Relationships

The discovery of *Sartor* makes the interrelationships of the group of genera to which it belongs somewhat clearer. All have a superior mouth, with the lower jaw vertical or inclined backwards when the mouth is closed. *Anostomus*, with four or five species, is the most widely distributed genus, and the least specialized. *Synaptolaemus*, *Sartor*, and *Gnathodolus* all seem to represent specializations of the *Anostomus* stem. The teeth have lost the deeply cuspidate character of those of *Anostomus*, although those of the upper jaw retain much the same position and the same number (4–4). Greater specialization is seen in the mandibular dentition. The teeth remain 4–4 in *Synaptolaemus*, but the anterior tooth on each side is enlarged and cuspless and the three posterior ones have become broad, sharp-edged, and procumbent, while still retaining the remnants of cusps. In *Sartor*, the specialization is much greater, the anterior tooth of each side being greatly enlarged and projecting far beyond the end of the jaw, and one posterior tooth has been lost on each side. The posterior teeth are procumbent and sharp-edged, but are not as broadened as those of *Synaptolaemus*. In *Gnathodolus* the four upper teeth are reduced in size and all of the mandibular teeth are gone except the symphysial pair, which are greatly elongated, and highly modified, being partly spoon-shaped and, in profile, sickle-shaped at the tip. In *Anostomus*, both upper and lower lips are thrown into numerous folds or plications, which divide the lip into a sort of fringe. In *Synaptolaemus* the plications of the upper lip are deeper and those of the lower are produced into a row of barbel-like papillae. The plicated upper lip of *Sartor* is much broader than in all the others, while the plications of the lower lip are developed into barbel-like papillae more extreme than those of *Synaptolaemus*. The plications of the upper lip are more numerous in *Gnathodolus*, and not as deep as those in the other genera, but the numerous, elongate, crowded papillae of the lower lip are better developed than those of *Sartor*.

*Anostomus*, *Sartor*, and *Gnathodolus* have the isthmus rather narrow; in *Synaptolaemus* it is proportionally about twice as wide as that of the others. In cross-section, the snout (midway between mouth and eye) of *Sartor* is nearly round, as in *Anostomus*; it is compressed (vertically ovate) in *Synaptolaemus*, and extremely deep and compressed in *Gnathodolus*. The lower jaw is broadest and shortest in *Anostomus*, narrower and longer in *Synaptolaemus*, and extremely narrow and elongate in *Sartor* and especially in *Gnathodolus*, in which the mouth opening approaches the proportions of a narrow vertical slit in the front of the head. The eye is almost at mid-position in the depth of the head in both *Anostomus* and *Gnathodolus*, noticeably lower in *Synaptolaemus*, and lowest of all in *Sartor*. But it is in the general *position* of the mouth that *Sartor* is by far the most extreme of the four genera. In this genus the mouth is pushed so far back upon the dorsal surface of the head that the lower jaw (with mouth fully closed) rests at an angle of approximately 45 degrees from the vertical! Finally, the caudal fin is symmetrical in three of the genera, but in *Gnathodolus* it is asymmetrical, with the upper lobe narrower and excised on its mediad margin. At least, it was so in two specimens from different localities; in the third example, the caudal was broken.

In color pattern, *Synaptolaemus*, with its chocolate-brown body and narrow orange-red rings, and *Anostomus anostomus*, with its light longitudinal stripes on a dark background, depart most notably from the usual anostomin pattern. However, it can easily be seen that the color patterns of the three monotypic genera are derivable from a common one. That of *Gnathodolus* recalls the pattern of *A. trimaculatus*.

*Anostomus anostomus* and *A. trimaculatus* are widely distributed throughout the Amazon system, the Orinoco, and the streams of northern Guayana. *A. plicatus* is known only from the Essequibo, where it occurs with its closest relative, *A. trimaculatus*. *A. gracilis* is known so far only from the Guaporé and Upper Orinoco. *Gnathodolus bidens* and *Synaptolaemus cingulatus* are known only from the types, from the general area of Mt. Duida and the Bifurcation, where the Rio Casiquiare

breaks away from the Upper Orinoco and flows south to join the Rio Negro. It seems probable that these two monotypic genera are confined to that part of Central Guayana.

On the other hand, the unique type of *Sartor respectus* has been found in the far southern headwaters of the Xingú, in the now low but ancient Planalto. This is approximately 2,000 km. air-line (and thrice or more that far by river) from the area whence *Gnathodolus* and *Synaptolaemus* come. While other related forms will undoubtedly be discovered, it seems possible that there have been at least two centers of specialization of these fishes, one to the north of the Amazon Basin, on the slopes of the Guayana Highland, and one in the southern part, in the streams of the Brazilian Highland.

Of the four genera, the senior author has seen only *Anostomus anostomus* in life. As with certain other anostomins, that species browses on algae growing on rocks and logs. In doing so, it often is seen standing vertically in the water, turning itself into many positions, often upside down, in order to scrape off its food. Some anostomins (*Abramites*, for example) habitually rest at an angle in the water, head down and tail up. It seems quite possible that both *Sartor* and *Gnathodolus* do so, possibly at an even greater angle than *Abramites*. It seems probable, also, that both *Sartor* and *Gnathodolus* feed whilst standing vertically (head down) or perhaps even upside down, but just what their enormously specialized symphysial teeth fit them to feed upon is problematical. For a fish resting or moving extensively in a head-down or vertical position, on or near the bottom, the advantage of posteriorly directed vision seems obvious.

### Literature Cited

Myers, G. S. 1927. Descriptions of new South American fresh-water fishes collected by Dr. Carl Ternetz. *Bull. Mus. Comp. Zool., Harvard 68: 107–135.* [Description of *Gnathodolus bidens.*]

———. 1950. The genera of anostomine characids. *Stanford Ichth. Bull. 3: 184–198.* [Figures of *Gnathodolus* and *Synaptolaemus.*]

Stanford University, California, and Museu Nacional, Rio de Janeiro, Brazil

# Ichthyological Notes

THE CRANIAL ANATOMY OF A FREE-LIVING POMACENTRID "CYCLOPEAN".—During the night of August 27, 1951, the Fish and Wildlife Service M/V *Oregon* collected fishes by means of a light and dipnet while anchored in deep water off Alacran Reef on the Campeche Banks of the Gulf of Mexico (Woods, *Copeia 1952(1): 40–41,* 1952). Among the juvenile fishes in this collection was a group of the genus *Eupomacentrus,* at present in the Chicago Natural History Museum (CNHM 64385). Mr. Woods noticed a one-eyed specimen in this group and generously turned it over to the author for study and for which I am indeed grateful.

This cyclopean specimen represents the second record of a vertebrate existing free-living with this condition. All other cases of cyclopia reported in the literature, produced either naturally or by experiment, failed to survive once their fetal food supply was used up or severed. The only other record of a free-living cyclopean is that of a ray (cartilaginous fish) reported by Paolucci (*Atti Soc. Ital. Sci. Nat. 17: 60–63,* 1874). An artificially reared monophthalmic hatchery trout which lived for 22 months has been reported by Yung (*Rev. Sussie Zool. 9: 307–13,* 1901).

*Morphological descriptions of adult pomacentrid skull.*—Through a study of the head skeletons of several members of the family Pomacentridae it is readily seen that the normal primary and secondary portions of the upper jaw (terminology of Gregory, *Trans. Amer. Philos. Soc. 23: 75–481,* 1933) are inter-related in a sliding series mechanism. As in most higher teleosts, the premaxillary bone constitutes the major element of the secondary upper jaw and bears the teeth. It slides on the antero-dorsal surface of the ethmoid complex through the agency of a cartilaginous bearing between the dorsal extension of the premaxillary and the ethmoid. The maxillary bone, situated generally dorso-lateral to the body of the premaxillary, has a saddle-like, medially directed, anterior end which fits over the body of the premaxillary just posterior to its dorsal extension. The palatine bone has a ventro-lateral projection at its anterior end which fits into a transverse groove on the dorsal aspect of the premaxillary saddle of the maxillary bone. Dorsally the palatine bone is articulated via

ligamentous connections with the ethmoid complex and the vomer. Posteriorly it is articulated to the ectopterygoid as part of the palato-quadrate complex (palatine, ectopterygoid, endopterygoid, mesopterygoid, and quadrate bones articulated in series) which forms the plate-like roof of the mouth. This palato-quadrate complex is associated in the mid-dorsal line of the mouth with the vomer and parasphenoid bones. Thus the premaxillary and maxillary bones of the secondary upper jaw are integrated into a sliding mechanism with the primary upper jaw (the palato-quadrate complex) to function with the special tooth row as a nibbling mechanism.

*Gross morphology of specimens* (*Figs. 1 & 2*).—Grossly this cyclopean specimen is indistinguishable from the other members of the group (presumably its siblings) with which it was captured. The single, median eye is the only major difference externally. The orbits are completely formed except for a narrow horizontal slit in the anterior portion of each. The olfactory organs are paired, one on each side, and are situated dorsal and lateral to the eye. The mouth appears to be normal except for a slight skewing to the left. Both the upper and lower jaws are complete. The upper jaw is separated from the eye by virtue of a deep transverse horizontal cleft which is continuous with the horizontal slits of the orbits.

The eye proper is situated in the middle of the anterior end of the head and is directed forwards. It is somewhat asymmetrical in that its left margin is attenuated laterally. In addition, there exists a trail of dark material extending back from the left side of the eye into the anterior area of the left orbit, There is no gross evidence of a double origin of this median eye.

*Microscopic morphology of specimens*.—Three specimens, 2 normal and the cyclopean, were serially cross-sectioned at 10$\mu$. All specimens were studied comparing the normal and cyclopean conditions. A projection apparatus was used to trace critical levels.

The normal specimens exhibit the same mechanical inter-relationships to be seen in the adult skeletons of this family. (Figs. 3*A*, 4*A* & 5*A*)

The cyclopean (Figs. 3*B*, 4*B* & 5*B*) demonstrates a very interesting difference from the normal in

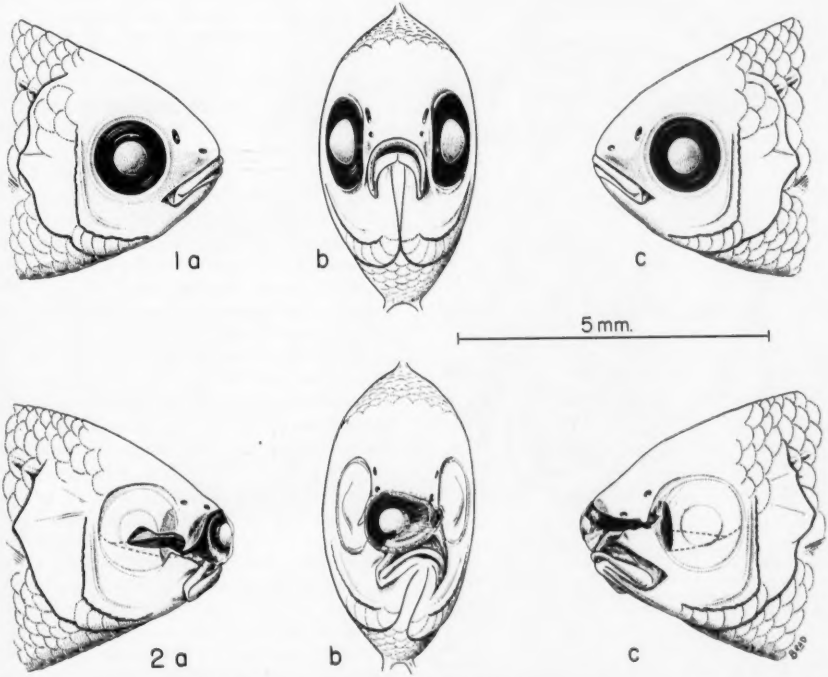



Fig. 1*a*, *b* & *c*.—Normal *Eupomacentrus* juvenile (8.4 mm. SL). Fig. 2*a*, *b* & *c*.—Cyclopean *Eupomacentrus* juvenile (8.7 mm. SL).

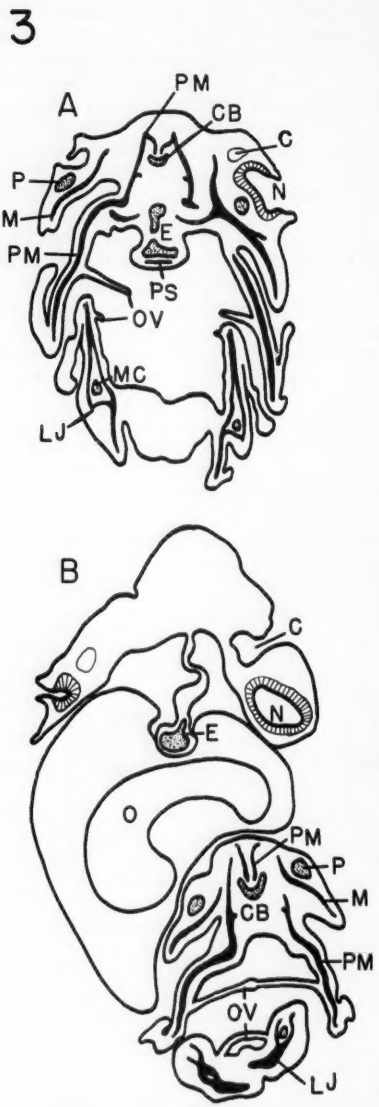



Fig. 3.—*A*. Normal sibling, *B*. cyclopean. Cross sections at the level of the anterior portion of the olfactory organs.

The sections of figures 3, 4 and 5 are selected from serial cross sections of the cyclopean and its normal sibling. These sections are actually slightly oblique so that the structures on the two sides are not in the same absolute level. Legend: C—sensory canal, CB—cartilage bearing, CC—cranial cavity, E—ethmoid complex, LJ—lower jaw, M—maxilla, MC—Meckel's cartilage, N—olfactory organ, P—palato-quadrate complex, PM—premaxilla, PS—parasphenoid, O—bulbus oculi, OM—extraocular muscle, OT—optic trail, OV—oral (breathing) valve.

that the upper jaw mechanism is intact but completely separated from the neurocranium throughout the ethmoid and orbital regions. The cartilaginous bearing is still associated with the tips of the dorsal extensions of the premaxillary bones but not with the ethmoid complex. The primary upper jaw (palato-quadrate complex) is still associated with the secondary (maxillary-premaxillary) but no longer articulates with the mid-ventral margin of the neurocranium so that a hiatus exists between the neurocranium and the roof of the mouth. The single eye is located in this hiatus with its trail extending into the left orbit.

The bulbus oculi of the cyclopean is of about normal dimensions but is asymmetrical. The trail consists of retinal material and continues as the optic nerve into the under surface of the right side of the brain. The extra-ocular muscles are developed on both sides but are very much reduced on the right. The myodome is consequently somewhat reduced also. The extra-ocular muscles actually associated with the existing bulbus oculi however are those of the left side only. The medial rectus muscle is thus forced to curve way to the right in order to maintain its "normal" relationships with the bulbus oculi.

The olfactory organs of the cyclopean are much as usual in position and relationships to the ethmoid region. Anteriorly both send nerves into the substance of the ethmoid cartilage but on the floor of the cranial cavity only the left olfactory nerve is evident (Fig. 4*B*).

The sensory canal system of the head of the cyclopean exhibits the usual relationships.

In this "freed" condition the cranium of the cyclopean has developed a large cavity forward. The brain, however, is not forward of the usual mid-orbital level. The right forebrain is smaller in cross-section than the left although in the midbrain it is the left side which is somewhat smaller. The pituitary body is present as usual.

*Discussion and conclusions.*—Because of the multiple and complex deformities associated with the condition of cyclopia (Adelmann, *Quart. Rev. Biol. 11: 161–82, 284–304,* 1936) it is exceptional to see, or expect to see, such an individual existing free-living and sustaining itself in nature. Except for the mythological cyclopeans, which are merely expressions of human imagination (Nelson, *Jour. Amer. Folklore 71: 159–61,* 1958), only one authentic case is recorded in scientific literature (Paolucci, *op. cit.*). Yung (*op. cit.*) reported a monophthalmic trout reared in a hatchery for 22 months but the circumstances are strictly artificial and it would certainly have died otherwise.

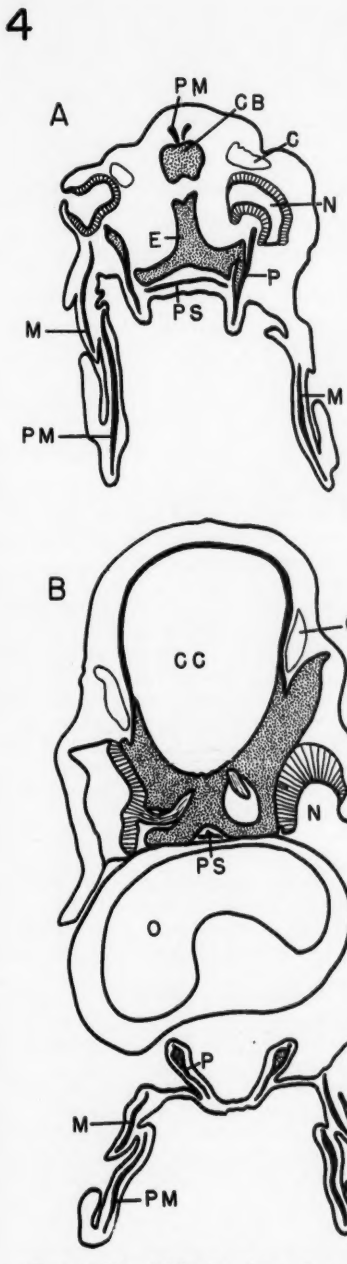



Fig. 4.—*A*. Normal sibling, *B*. cyclopean. Cross sections at the level of the anterior neurocranium.

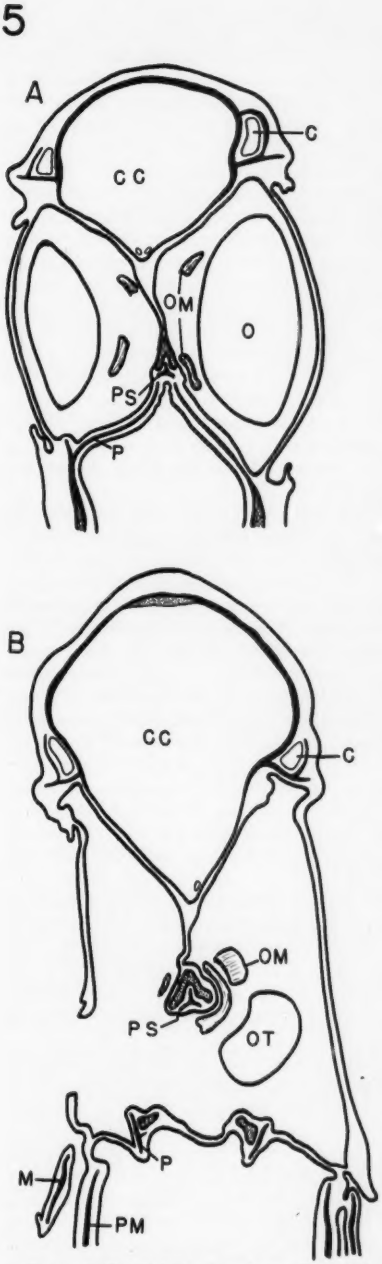



Fig. 5.—*A*. Normal sibling, *B*. cyclopean. Cross sections at the level of the mid-orbit.

That this cyclopean specimen here described was free-living is evidenced by several facts. Brinley (*Copeia 1939(4): 185–88,* 1939) and others have indicated that pomacentrid eggs are deposited on or near the shallow reefs during June, July, and August. This specimen was collected in the planktonic phase of its life cycle out over deep water in late August (Woods, *op. cit.*). At hatching the young of this family are about 3 mm. in length—presumably total length (Brinley, *op cit.*; Shaw, *Copeia 1955(2): 85–89,* 1955) whereas these specimens were nearly 10 mm. in total length. In morphology these specimens were well into the juvenile stage. No food was obvious in the continuous gut tract but this was also true for the siblings. It is presumed, however, that they must have eaten since they grew to 3 times their hatching size, and the yolk is practically all gone at hatching. Altogether it would appear that this cyclopean was 2–3 weeks post-hatching in age when caught and was free-living during that time.

Along with the fact of being free-living the possibility is good that this cyclopean has visual ability. It came to the light and it was a member of a school, which usually is based upon visual cues. The single eye was continuously connected to the brain via the retinal trail and optic nerve. Rogers (*Biol. Bull. 112: 241–48,* 1957) demonstrated visual ability in a synophthalmic *Fundulus* in which the left eye was functional, the right eye degenerate. The left eye, however, was not in the mid-line and the *Fundulus* had a tendency to turn in reaction much as did Yung's monophthalmic trout. This *Eupomacentrus* cyclopean had its single eye in the center of the front of its head and the visual fields may well have become adjusted for good forward locomotion and food-getting.

An analysis of the over-all situation, however, leads to the conclusion that this specimen is not a true cyclopean but rather a situation in which the right eye very early lost its bulbous oculi and the left eye swung into the mid-line separating the branchiocranial elements as a unit from the neurocranium.

That the single eye was the left one may be concluded from the facts that it has a trail of retina into the left orbit, only the left optic nerve is present crossing over into the right brain, and the extra-ocular muscles actually associated with the bulbus oculi are those of the left side.

As to the relative time during ontogeny that this situation developed is somewhat difficult to ascertain. From the well developed orbits and the presence of 2 sets of extra-ocular muscles it would seem that both eyes were originally formed, but that the bulbus oculi of the right was lost. From the presence of the well developed premaxillary bones characteristic of the higher teleost, secondary upper jaw complex, it is clear that the fronto-nasal process had completed its antero-lateral migration and was not blocked by the single, median eye as would be the case in true cyclopia. To have the left eye migrate into the mid-line however would indicate an early time when the parts were still plastic and the skeletal elements could be easily moved aside.—EDWARD M. NELSON, *Department of Anatomy, Stritch School of Medicine, Loyola University, Chicago, Illinois.*

A CASE OF "SCHOOLING" BEHAVIOR IN THE PRICKLY SCULPIN, *COTTUS ASPER* RICHARDSON.—Freshwater cottids are usually regarded as non-schooling fishes which become territorial early in their life history. The following observations describe a possible case of schooling in the prickly sculpin.

On the morning of July 17th, 1958, a moving band or "stream" of prickly sculpins was noted along a section of shore line in Nicola Lake, near Merritt, British Columbia.

The sculpins appeared in a more or less continuous stream extending at least 0.7 miles along the steep rocky southwest shore of the lake. A similar phenomenon was observed at the same location on the afternoon of July 18th, 1958, but was not seen again during subsequent periodic checks along the twelve-mile length of the lake.

On the morning of July 17th, Nicola Lake was calm, but along the shore where sculpins were moving, a slow flow (less than two feet per minute) was noted in the upper foot of water by observing movement of algae strands and other suspended particles. This flow was in a southwest direction, directly opposite to that of the sculpin movement. On the afternoon of July 18th, the lake was slightly rippled by a light southwest wind, but no surface nor subsurface flow was noted.

Water temperature, measured on the afternoon of July 18th, ranged between 25.6 and 26.7° C. within the area in which the band of sculpins moved (Figure 1).

On both days the band of sculpins was moving in a northeast direction along the shore towards the head of the lake. Horizontal and vertical distribution of the sculpins along the shore is shown schematically in Figure 1. The band was concentrated near the margin of the shore where most individuals swam within a few inches of the surface. Farther offshore fewer sculpins were evident and these appeared only near the bottom. Underwater observation made with diving equipment at depths of ten to twelve feet

revealed only a few large sculpins on the bottom. These individuals did not appear to be associated with the band of smaller sculpins moving above. The stream of sculpins, although virtually continuous (while observed passing one point for at least fifteen minutes), was not of uniform density along its length. Groups of twenty to thirty individuals were followed by fewer individuals in a less dense grouping.

In some sections the shore line was formed by sheer rock faces broken by large V-shaped indentations over five feet in length and about three feet across the mouth. The band followed these indentations a few inches off the face of the cliff, provided they were in direct sunlight. Where notches were in complete shade, however, the band did not enter but swam directly across the mouth along the edge of the shadow.

Frequently several individuals dropped out of the moving band to settle temporarily upon rocks or branches which projected above the bottom. Sculpins often settled upon an arm or hand held underwater across the path of the band. These individuals usually joined other groups swimming above within a few seconds.

Counts were made of the number of sculpins crossing a strip two feet in length set at right angles to the shore. Counts on such a strip recorded many of the sculpins passing a given point along the shore line, but did not include those deeper and farther off-shore (see Figure 1). Counts ranged between 100 and 200 individuals per minute, indicating the large number of sculpins involved in the movement along the shore. Individual sculpins within the band swam at four to five inches per second over a two-foot section where swimming speeds were timed.

Associated with the band of sculpins and moving in the same direction were schools of small cyprinid and catostomid fry. Although these schools tended to keep pace with the sculpins their movement was more erratic. On both days sculpins were seen chasing individual fry. Several sculpins were noted with small objects projecting from their mouths which may have been tails of cyprinid or catostomid fry. Collections of "schooling" sculpins and associated cyprinid and catostomid fry were made by dip-netting on the afternoon of July 18th. Length data for the collections are summarized in Table 1.

Prickly sculpins collected were probably all yearling fish. Fry of the year taken elsewhere from Nicola Lake were of a distinctly smaller size group. Sculpins of the July 18th Nicola collection fell within the yearling size group recognized by Northcote (*Copeia 1954 (1): 25–28*) for this species in the Arrow Lakes. On the other hand schooling cyprinids and catostomids associated with the band of "schooling" sculpins probably were all fry of the year.

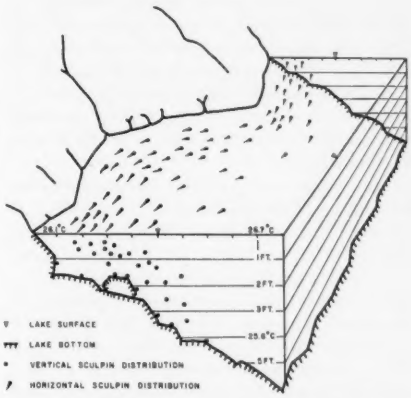



Fig. 1.—Schematic representation of vertical and horizontal distribution of prickly sculpins moving along rocky shore of Nicola Lake, B.C., as observed on 18th July, 1958.

TABLE I

LENGTH DATA FOR PRICKLY SCULPINS, CYPRINID AND CATOSTOMID FRY COLLECTED FROM SOUTHWEST SHORE OF NICOLA LAKE ON JULY 18TH, 1958

| Species | Number Collected | Average fork Length (MM.) | Range in fork Length (MM.) |
|---|---|---|---|
| Prickly sculpin (*Cottus asper*) | 151 | 32.3 | 26–39 |
| Northern squawfish (*Ptychocheilus oregonense*) | 18 | 21.6 | 18–24 |
| Largescale sucker (*Catostomus macrocheilus*) | 15 | 22.0 | 20–24 |
| Peamouth chub (*Mylocheilus caurinum*) | 1 | — | 26 |
| Redside shiner (*Richardsonius balteatus*) | 1 | — | 24 |

Stomach contents of fifty prickly sculpins from the collection were examined. Fifteen of the individuals had no recognizable food material in the stomach. Of the remainder, 66% contained chironomid larvae or pupae, 31% contained trichopteran larvae, and 17% contained plankton. No fish remains were found in any of the stomachs examined, although several sculpins were observed in the band with what appeared to be small fish tails projecting from their mouths.

Both male and female sculpins were present in the band moving along the shore. Sex determination of one hundred individuals from the collection gave sixty males and forty females.

The significance of this unusual "schooling" behavior in prickly sculpins or the factors causing it are not obvious. Aggregations of the Aleutian sculpin (*Cottus aleuticus*) have been reported in Karluk Lake by Greenback (*Copeia 1957 (2): 157*), although in this case the fish were not moving nor was the aggregation a stable one. At Nicola Lake the presence of a boat overhead, or a dip-net or person in the water along the shore, did not seriously disturb passage of the moving band of sculpins.

Most recent concepts of fish schooling reviewed by Keenlyside (*Behaviour 8: 183–248*, 1955), require an attraction between individuals rather than external environmental factors as causal agents. The band of sculpins observed at Nicola Lake may have formed as a result of group feeding upon a schooling prey. Nevertheless the sculpins which made brief chases after young cyprinid or catostomid fry quickly returned to their band and appeared to orient more with the latter than with the schools of other species. Furthermore, sculpins dropping temporarily out of the moving band, appeared to react and orient to other groups of sculpins when rejoining the band. Prickly sculpins, as observed moving along the shore of Nicola Lake, gave every appearance of schooling.

The assistance of Dr. C. C. Lindsey in making field observations and reading the manuscript is appreciated.—T. G. Northcote and G. F. Hartman, *Fish and Game Branch, Department of Recreation and Conservation, 567 Burrard Street, Vancouver, B.C., Canada.*

A CARIBBEAN CHAETODONT FISH, *CHAETODON EQUES* STEINDACHNER, NOW REFERRED TO *CHAETODON AYA* JORDAN.—Very recently Carl L. Hubbs and A. B. Rechnitzer (*Proc. Calif. Acad. Sci., ser. 4, 29: 273–313*, 1958) described at considerable length a new species, *Chaetodon falcifer*, from Guadalupe Island off the Pacific Coast of Mexico. They pointed out the close relationship of the new fish to *C. aya* Jordan of the western Atlantic and *C. marcellae* Poll of West Africa, and attempted a complete survey of the literature on these related species. They also listed the known specimens and gave what they believed to be the first published illustrations of the previously little known *C. aya*. These figures recalled strongly a description and beautiful lithographic plate of a similar tropical American chaetodont published by Franz Steindachner over 50 years ago but not mentioned by Hubbs and Rechnitzer. Their synonymy of *C. aya* (*pp. 300–301*) should be amended by the following addition:

*Chaetodon aya* Jordan 1886

*Chaetodon eques* Steindachner, 1903, Sitzb. kaiserl. Akad. Wiss. Wien, mathem.-naturw. Klasse (1) 112: 18, pl. (unnumbered), fig. 1 (original description; type locality: coast of Yucatan; holotype in Hofmuseum, Wien).—Ahl, 1923, Archiv f. Naturg., (A) 89 (5): 123 (after Steindachner).

Comparison of Steindachner's description and figure of the 100 mm. type in the Vienna Museum with Hubbs and Rechnitzer's Table 1, and with their new account and figures of *C. aya*, leaves no reasonable doubt that *C. eques* is a synonym of *C. aya*. Steindachner gives the following fin counts: D. XIII, 20; A. III, 16. From his excellent illustration the principal caudal rays appear to be 16, the pectoral count 14, and the pelvic I, 5. He says there are about 40 scales in a horizontal row between the upper end of the gill opening and the caudal base, the scales rapidly diminishing in size from shortly before the beginning of the caudal peduncle. The slight difference to be noted (40 versus 32 to 38) is probably due to different methods of counting. The pored scales of the lateral line are given as 26 on one side and 29 on the other. The color pattern is exactly typical of *aya*. Other characters given by Steindachner or shown in his figure agree well with those given by Hubbs and Rechnitzer for *C. aya*. Steindachner refers to Jordan's species but it must be recalled that *aya* was known at the time only from the published descriptions of the small holotype taken from the stomach of a snapper, *Lutianus aya*.

The overlooking of Steindachner's paper, not only by Hubbs and Rechnitzer, but also by Jordan, Evermann and Clark in the checklist, was perhaps due to the omission of a reference to *C. eques* in the Zoological Record. However, an account of *C. eques* immediately follows that of *C. aya* in Ahl's monograph of 1923.—George S. Myers, *Natural History Museum, Stanford University, California.*

OBSERVATIONS ON *PTEROIS VOLITANS* (L.) AND ITS VENOM.—A recent note (Ray and Coates, *Copeia 1958 (3): 235*) concerning the dangerous effect of the lion fish, *Pterois volitans* (Linnaeus), induces me to publish, for comparison, the observations I made after having been stung by a specimen of the same fish, on November 29, 1955, at Eylath (Gulf of Aqaba), Red Sea. My original notes were written down 2 hours and 40 minutes after the incident. While I could keep track of the events, from looking at my watch, I was unable to make written notes before that

time. I use this opportunity to report also on an interesting aspect of the behavior of this species.

While swimming just a few meters off the beach, over a depth of about 2 to 3 meters, I saw a young *Pterois volitans* (about 10 cm. long), quietly swimming nearby. *P. volitans* is a common fish in the area, but rather rare over sandy bottom remote from rock formations. It is also rare to find it swimming in mid-water. When I stretched out my arm toward the fish, trying to seize it by the pectoral fin, the fish abruptly rotated about its axis, thereby bringing its dorsal fin spines close to my fingers. Evading the fish's dorsal spines, I quickly tried to approach its ventral side while it was still "lying on its side." However, after a sudden half turn of the animal, its dorsal spines once more almost touched my fingers, while the fish was now lying on its other side. I had previously observed numerous individuals of this species, but had never noticed a reaction similar to this, when they were resting on the bottom. I was, therefore, interested to see how regular this response was. I repeated my approaches several times, and it became clear that the fish, while suspended in mid-water, reacts to an object moving closely towards it from the side, by confronting it with its dorsal spines. This is brought about by rotation of the body about 90 degrees from the normal position (dorsal side up) or, by a 180 degrees' rotation starting from the lateral side-up position.

However, although the fish was in an exceptional situation, it still had some advantage inasmuch as it moved more rapidly than I was able to, and, worse, more rapidly than I had calculated. My experiments came to a sudden end when I saw, rather than felt, that I had been stung by tips of two of the dorsal spines in the distal phalanx of my right forefinger. The act of stinging was scarcely appreciable, and by no means painful. But from the volar side of the phalanx, near to its tip, at once, two fine threads of blood could be seen running down into the water. I squeezed out more blood. Then I left the water to look for my clothes. I had to walk for some hundred meters and, meanwhile, pains set in, but remained very moderate. However, about 10 minutes after I had been stung, the pain increased rapidly; it was now a sharp cutting pain, throughout the whole finger, but particularly heavy along its dorsal side. Very soon, the middle finger became involved. It was conspicuously pale compared with the unaffected fingers of the hand, but at the same time the forefinger had reddened beyond the color of the rest of the fingers. The forefinger now began to swell and the pain still grew. About half an hour after the sting had occurred, pains were almost unbearable. At this time even the thumb of my right hand was involved, but in it pains were intermittent and remarkably less strong. I noticed a few more symptoms. The skin of the terminal phalanx of the forefinger was almost insensitive to touch, and the slightest touch on the intermediate and basal phalanx was extremely unpleasant. Likewise hyperalgesic was the radial side of the third finger; less but still appreciably hyperalgesic was the dorsal and the volar side of the thumb.

Since I had no specifically analgesic drug with me, and medical assistance was unavailable, all I could do was to swallow the last 1½ headache pills I found (In this case, this amounted to 0.38 g. acetylsalicylic acid, 0.38 g. phenacetin, and 0.015 g. codeine phosphate).

I was not aware of any other local or general symptom. The pulse was entirely normal, no headache or nausea. Under these circumstances, I was certain that the process was strictly limited, but the local condition appeared nonetheless unbearable. I was tortured by pains beyond measure, and yet the pain was still growing more intense. It sent me running. I tried to sit down, to lie on the ground, to stand still. The pain would not let me. I had to move on, to run about. It is a strange experience recognizing quite lucidly that nothing fatal has happened to oneself, and feeling at the same time, that this was much worse than anything previous. In fact, it is just short of driving oneself completely mad.

This state of affairs lasted for some time. About 1½ to 2 hours after the sting (it was impossible to determine the onset of the next phase any better), pains began to subside slowly. Gradually the thumb became painless, and after it, the third finger. The forefinger was still very painful at that time, but quite obviously less than before. Shortly afterwards, the third finger could be moved freely, only occasionally was it painful. Almost 3 hours after the sting, the forefinger was not yet normal, but pain was fair; the terminal phalanx was swollen and very warm, the swelling preventing even slight movement; the mid-phalanx was markedly less swollen. Further recovery was fast so that 3 hours after the sting the pain was negligible.

In the note on *Pterois* sting, referred to above, we find several details particularly interesting in their similarity to what has been reported here, although it is obvious that the accident and its consequences were, on the whole, of a more serious character. There was pain described "as almost unbearable" in both cases. Likewise, there was reddening and swelling of the region in-

volved, and insensitivity to touch developed over the whole or part of the area.

The restlessness exhibited in both cases may also be significant, although it is open to question whether this was a symptom of the direct involvement of the central nervous system, or whether it should be interpreted as a voluntary attempt of the sick person to fight against the intense pain. It is probable that a fast spreading factor exerting a strong action upon the sensory nerves of the area is involved. It also appears that this factor is relatively short-lived, being destroyed or otherwise eliminated after about 3 hours. Subsidence of the pain can hardly be attributed to the headache pills taken in the one case, or the epinephrine administered in the second. It is obvious that the factor affecting the nerves, or an admixed one, promote hyperemia and edema. It is, however, not certain the *Pterois* venom attacks the central nervous system causing excitation of the motor centers.

The over-all effect of the *Pterois* sting appears to depend on the amount of venom injected. Stings from 3 spines of a specimen of 12.5 cm. length, penetrating for about 3 mm., resulted in pains attaining greatest intensity 10 minutes after the accident, in a heavily swollen hand 15 minutes after the sting, and pains reaching up to neck and chest. However, stings from 2 spines of a smaller specimen, penetrating certainly less deep, resulted in pains reaching their height 30 minutes after the sting, never extending beyond part of the hand, and moderate swelling restricted to one finger.—H. Steinitz, *Department of Zoology, The Hebrew University of Jerusalem, Israel.*

A PELAGIC RECORD OF THE SNIPEFISH, *MACRORHAMPHOSUS SCOLOPAX* (L.), IN THE GULF OF MAINE.—At 0850 on May 4, 1958, latitude 40°56′ north, longitude 66°52′ west, in 49 fathoms, a single specimen of the snipefish (*Macrorhamphosus scolopax*) was taken in a surface meter net haul from the Fish and Wildlife Service Research Vessel, *Albatross III*. The specimen was a juvenile; total length 51 mm., standard length 46 mm.

Fig. 1.—*Macrorhamphosus scolopax* (L.), a juvenile 46 mm. in standard length, taken in a surface net tow.

Published records of the occurrence of this species from both the Mediterranean and Eastern and Western Atlantic indicate it to be an inhabitant of at least moderate depths (below 120 meters). The fact that this fish was taken at the surface makes it worthy of note.

The coloration is also of interest. The normal color of the adults has been variously described by several authors as pink, red, orange, or golden above, shading to silver or white below. Our specimen, however, was deep blue above, shading to silver below. Both the size and color of this fish suggest a pelagic development of the eggs and larvae of this species.

The specimen has been deposited in the collection of the U. S. National Museum (USNM 185479).—David Miller, *U. S. Fish and Wildlife Service, Woods Hole, Massachusetts.*

AGE, GROWTH, AND FOOD OF THE LONGNOSE DACE, *RHINICHTHYS CATARACTAE*, IN NORTHWESTERN PENNSYLVANIA.—On September 12, 1957, Little Sandy Creek in Venango County, Pennsylvania, was chemically reclaimed by employees of the Pennsylvania Fish Commission. Before this project was undertaken electro-sampling had established that the longnose dace was one of the most common cyprinids present. Plans were made to have a crew recover this species during the reclamation.

A 1,550-foot section of the stream was walked off and an attempt was made to have a complete pick up of *cataractae* in that .9-acre area. The number of square feet in the riffle habitat in this section was determined. Samples were collected of all fish-life eradicated in the section and a record taken of their relative abundance.

This paper deals with some phases of its life history, including age and growth, food, associates, and density.

*Description of habitat.*—Little Sandy Creek is a small, spring-fed, trout stream which flows through a well wooded valley near the town of Polk in Vanango County. It is the main tributary of Big Sandy Creek, a stream that has been polluted for many years by acid discharge from several abandoned deep mines near its headwaters. Since this pollution serves as a barrier for Little Sandy Creek, the various fish life living in Little Sandy prior to reclamation was an indication of existing conditions before man entered the region.

The adults of *cataractae* were usually collected in the lower portion of riffles during the electrosampling of the area. Immature specimens were abundant in the shallow pools. Although this species is not uncommon in northwestern Pennsylvania, the numbers sampled in Little Sandy far surpassed any other water area in the region.

This observation is based on data collected during the electro-sampling and/or chemical sampling of all the major water systems in the northwest region of Pennsylvania.

*Growth rate.*—From the experimental section 1,034 *cataractae* adults were collected and preserved in 10% formalin. Scales taken from the mid-side of the body above the lateral line were aged and the total length of each specimen recorded. The lengths of the sexes by year classes are given in Table 1. The largest male from Little Sandy was 96 mm. in total length and the largest female examined was 118 mm.; these values are similar to those recorded by Kuehn (*Proc. Minn. Acad. Sci. 17: 81–83,* 1949) for Minnesota. In his study of several longnose dace populations he reported a maximum age of four years in the males and five years for the females.

TABLE 1

LENGTH FREQUENCIES, SEX RATIOS AND THE PROBABILITY FOR VALUES OF CHI-SQUARE THAT A SIGNIFICANT DEPARTURE FROM THE 1 TO 1 SEX RATIO OCCURRED IN 1,034 ADULTS OF *RHINICHTHYS CATARACTAE* COLLECTED FROM LITTLE SANDY CREEK, POLK, PENNSYLVANIA ON SEPTEMBER 12, 1957

| Total length in millimeters | Age | | | | Classes | | | | | | Total for all age classes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I+ | | II+ | | III+ | | IV+ | | V+ | | | | |
| | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ + ♀ |
| 48 | 3 | — | — | — | | | | | | | 3 | — | 3 |
| 50 | 2 | — | — | — | | | | | | | 2 | — | 2 |
| 52 | 6 | 7 | — | — | | | | | | | 6 | 7 | 13 |
| 54 | 7 | 6 | — | — | | | | | | | 7 | 6 | 13 |
| 56 | 10 | 16 | — | — | | | | | | | 10 | 16 | 26 |
| 58 | 11 | 36 | — | — | | | | | | | 11 | 36 | 47 |
| 60 | 30 | 22 | — | — | | | | | | | 30 | 22 | 52 |
| 62 | 31 | 16 | — | — | | | | | | | 31 | 16 | 47 |
| 64 | 14 | 9 | 3 | — | — | — | | | | | 17 | 9 | 26 |
| 66 | 3 | 1 | 3 | 2 | — | — | | | | | 6 | 3 | 9 |
| 68 | | | 2 | 3 | — | — | | | | | 2 | 3 | 5 |
| 70 | | | 4 | 6 | — | — | | | | | 4 | 6 | 10 |
| 72 | | | 7 | 9 | — | — | | | | | 7 | 9 | 16 |
| 74 | | | 20 | 18 | 3 | — | — | — | | | 23 | 18 | 41 |
| 76 | | | 20 | 19 | 4 | 3 | — | — | | | 24 | 22 | 46 |
| 78 | | | 18 | 33 | 17 | 6 | — | — | | | 35 | 39 | 74 |
| 80 | | | 13 | 16 | 30 | 13 | — | — | | | 33 | 39 | 72 |
| 82 | | | 10 | 4 | 39 | 31 | 1 | — | — | — | 50 | 35 | 85 |
| 84 | | | 3 | 3 | 27 | 28 | 6 | 2 | — | — | 36 | 33 | 69 |
| 86 | | | | | 7 | 27 | 18 | 11 | — | — | 25 | 38 | 63 |
| 88 | | | | | 3 | 19 | 18 | 36 | — | — | 21 | 55 | 76 |
| 90 | | | | | 2 | 8 | 11 | 37 | — | — | 13 | 45 | 58 |
| 92 | | | | | — | 3 | 14 | 27 | — | — | 14 | 30 | 44 |
| 94 | | | | | | | 5 | 16 | — | 5 | 5 | 21 | 26 |
| 96 | | | | | | | 3 | 18 | — | 8 | 3 | 26 | 29 |
| 98 | | | | | | | — | 9 | — | 13 | — | 22 | 22 |
| 100 | | | | | | | — | 4 | — | 13 | — | 17 | 17 |
| 102 | | | | | | | | | — | 15 | — | 15 | 15 |
| 104 | | | | | | | | | — | 9 | — | 9 | 9 |
| 106 | | | | | | | | | — | 6 | — | 6 | 6 |
| 108 | | | | | | | | | — | 4 | — | 4 | 4 |
| 110 | | | | | | | | | — | 1 | — | 1 | 1 |
| 112 | | | | | | | | | — | 1 | — | 1 | 1 |
| 114 | | | | | | | | | — | 4 | — | 4 | 4 |
| 116 | | | | | | | | | — | 2 | — | 2 | 2 |
| 118 | | | | | | | | | — | 1 | — | 1 | 1 |
| Totals | 117 | 113 | 103 | 113 | 132 | 137 | 76 | 160 | — | 82 | 427 | 604 | 1034 |
| Mean length | 59.0 | 58.3 | 75.2 | 76.1 | 81.0 | 84.0 | 87.1 | 90.3 | — | 101.3 | | | |
| Sex ratio | 1.03:1 | | .91:1 | | .95:1 | | .47:1 | | .0:1 | | | | |
| Chi-square | .06 | | .46 | | .14 | | 29.80* | | 82.00* | | | | |
| Probability | .975 | | .50–.70 | | .950 | | .01 | | .01 | | | | |

* Highly significant at the 1% level of confidence from the 1 to 1 ratio.

The Little Sandy Creek population of *cataractae* exhibited the same limitation in age (Table 1).

*Sex ratio.*—Sex was easily ascertained by the apparent ripe condition of the gonads. Eggs were observed in the ovaries and the testes noted to be quite thickened. When picked up on September 12, the males were pinkish around the base of the pectorals; the sides of the head and the snout and the lips were brightly colored. Females were yellow in the same areas.

A chi-square test was used to establish a possible significant departure from the 1 to 1 sex ratio (Table 1). The number of males showed a marked decrease in the IV+ age class and were absent from the V+ age class. No significant departure from the 1 to 1 sex ratio occurred in the first three age classes.

*Food habits.*—The material present in each dace stomach was examined under a binocular microscope and separated into six categories. Results are shown in Table 2 for each of the five age classes. Almost 90% of the food was composed of adult or immature stages of simulids, chironomids, and ephemerids. Kuehn (*ibid.*) also reported the species to be almost entirely insectivorous, based on collections he had taken in June.

TABLE 2

FREQUENCY OF OCCURRENCE OF CATEGORIES OF MATERIAL IN STOMACH CONTENTS OF 796 ADULT *Rhinichthys cataractae* FROM LITTLE SANDY CREEK ON SEPTIEMBER 12, 1957

| Age | No. of stomachs with food | Empty | Diptera | Ephemerida | Other insecta | Annelid worms | Algae | Debris* |
|---|---|---|---|---|---|---|---|---|
| | | | % | % | % | % | % | % |
| 1 | 143 | 28 | 63.5 | 27.8 | 1.3 | .5 | .7 | 6.2 |
| 2 | 150 | 31 | 56.8 | 32.8 | 2.7 | .8 | .8 | 6.1 |
| 3 | 181 | 39 | 61.0 | 33.1 | .5 | .4 | .7 | 4.3 |
| 4 | 153 | 26 | 69.2 | 22.7 | 1.3 | 1.1 | 1.8 | 3.9 |
| 5 | 40 | 5 | 59.3 | 23.6 | 2.0 | 5.2 | .1 | 9.8 |
| Totals Average | 667 | 129 | 61.9 | 28.0 | 1.6 | 1.6 | .8 | 6.1 |

* Bark, leaves and sand were included in this category.

*Associated species, carrying capacity, and density.*—The number of specimens sampled only with the electro-shocker was recorded from the 1,550 foot section. No brown trout over six inches were counted, and the sample was restricted to the riffle habitats. The former restriction eliminated any possible stocked brown trout since the Pennsylvania Fish Commission stocks only trout six inches or more in length.

In order of relative abundance the following species were recorded: *Catostomus c. commersoni, Hypentelium nigricans, Cottus b. bairdi, Rhinichthys cataractae, Rhinichthys atratulus meleagris, Campostoma anomalum pullum, Etheostoma z. zonale, Etheostoma blennioides,* and *Salmo trutta.*

Little Sandy Creek had an estimated carrying capacity of 115 pounds of fish life per acre at the time of reclamation. Trout made up an estimated 35 pounds of this figure. This information is based on the pick-up following reclamation. By way of comparison, the trout streams in the Allegheny National Forest of Pennsylvania have estimated carrying capacities of trout and other fish that range from 10 to 35 pounds per acre (Boccardy, *personal communication*).

From several "mark and recapture" study areas on Little Sandy it was determined that a 90% pick-up had been realized for the longnose in the 1,550-foot experimental area. This figure was used to establish the density of dace in the riffle habitat. The section had 39,200 square feet of water surface on September 12, of which 14,250 square feet was riffle habitat. A total of 1,034 adult longnose were picked up from the area. An estimated 1,137 adults were actually present in this area as based on the 90% pick-up. Therefore, it was estimated that there were .08 adult dace per square foot of riffle habitat at the time of reclamation.

*Acknowledgments.*—The author wishes to thank Gordon L. Trembley of the Pennsylvania Fish Commission for his cooperation during this project. A word of appreciation is due to Joseph Boccardy of the United States Fish and Wildlife Service who introduced me to chemicals as a management tool.—ROGER J. REED, *Associate Biologist, Alaska Department of Fish and Game, Kodiak, Alaska.*

**PARASITIC LAMPREYS (*ICHTHYOMYZON*) FROM THE MISSOURI RIVER, MISSOURI AND SOUTH DAKOTA.**—In preparation of their revision of *Ichthyomyzon*, Hubbs and Trautman (*Misc. Publ. Mus. Zool. Univ. Mich. 35: 1–109*, 1937) examined all museum material of the genus known to them, but they saw no specimens of any species from the Missouri River drainage. They cited (*op. cit.: 72–73*) the following literature records: Mill Creek, Shawnee and Wabaunsee counties, Kansas (reported as *Petromyzon castaneus* by Cragin in 1885); Marais des Cygnes, Ottawa, Kansas (reported as *Petromyzon argenteus* by Wheeler and by Cragin in 1878 and 1885); and Crow Creek, Chamberlain, South Dakota (reported as *Ichthyomyzon concolor* by Evermann and Cox in 1896).

These reports were assigned to the synonymy of *Ichthyomyzon castaneus* with some reservation, most bearing the footnote reference "Identification based on locality, with more or less evidence of a circumstantial, confirmatory nature." Hubbs and Trautman's distribution map shows *Ichthyomyzon castaneus* covering all of the above localities and most of the eastern halves of Kansas, Nebraska, and the Dakotas. *I. unicuspis* is indicated to enter the Missouri River in eastern Missouri. In his unpublished survey (1942) of the fishes of Nebraska, Dr. Raymond Johnson saw no lampreys, but heard verbal reports from fish hatchery employees of lampreys attached to fishes in the Missouri and lower Platte rivers of that state.

Although the paucity of reports indicates that lampreys are rare in the Missouri System, recent accessions from that drainage basin by the Museum of Zoology of the University of Michigan include four species of *Ichthyomyzon*. The two non-parasitic species will be reported elsewhere, the two parasitic species herein. Both *Ichthyomyzon castaneus* and *I. unicuspis* are known to be sympatric inhabitants of the Mississippi River at St. Louis near the mouth of the Missouri (Hubbs and Trautman, *op. cit.*: *60*, *76*). The new records document the penetration of the Missouri River by both species. But contrary to the expectation of Hubbs and Trautman, it is *Ichthyomyzon unicuspis* that apparently extends farther upstream.

*Ichthyomyzon unicuspis* Hubbs and Trautman. Silver lamprey.—UMMZ 177298, a metamorphosed female 211 mm. in total length with numerous developing eggs, was collected in the Missouri River at Vermillion, South Dakota, on September 9, 1925, by A. Hugener. This lamprey was found in the Over Collection of the University of South Dakota (No. 16955) by Dr. James C. Underhill, through whose courtesy it has been placed in the Museum of Zoology collection on permanent loan.

The specimen is a soft and faded alcoholic. It shows no evidence of concentration of dark pigment around the lateral-line sense organs. The distal part of the tail is rather heavily pigmented with melanophores that extend almost to the margin of the fins and is especially dark below the body axis. The transverse lingual lamina is strongly bilobed with a deep notch (as shown in Hubbs and Trautman, Fig. 3, lower right). Circumoral teeth 19, of which one is notched near its tip and countable as bicuspid, the others unicuspid; supraoral lamina bicuspid; infraoral lamina with 8 cusps; lateral teeth 6 (left) and 7 (right); teeth in anterior row 3; myomeres about 54. The following measurements are expressed as thousandths of the total length (211 mm.): tail length 299; depth of body 87; length of eye 12; length of snout 97; length of disk 95; and length over gill apertures 104.

*Ichthyomyzon castaneus* Girard. Chestnut lamprey.—UMMZ 158772, a metamorphosed male 160 mm. in total length, was collected in the Missouri River, Herman, Gasconade County, Missouri, on June 12, 1945, by H. J. Fisher. UMMZ 158773, 2 metamorphosed males 150 and 190 mm. long, collected at the same locality on June 10, 1945, by Fisher.

These three specimens are firm and well preserved. All show notable concentration of black pigment around the lateral-line sense organs. The distal part of the tail is darkened, and diffuse pigmentation extends outwards to or nearly to the fin margin. The transverse lingual lamina consists of two gentle arcs that meet at a broadly obtuse angle. The two smaller specimens resemble the lower left diagram of Hubbs and Trautman's Figure 3, the largest specimen looks like that shown in the upper left. The three specimens have the following counts respectively: circumoral teeth 21, 23, 22; bicuspid circumorals 12, 8, 7; supraoral cusps 3, 3, 2; infraoral cusps 10, 10, 10; lateral teeth 8–8, 10–10, 9–9; teeth in anterior row 6, 6, 6; myomeres 56, 53, 54. The following measurements are expressed as thousandths of the total length (160, 150, and 190 mm.): tail length 289, 297, 314; depth of body 81, 71, 73; length of eye 13, 13, 14; length of snout 111, 101, 91; length of disk 100, 91, 78; length over gill apertures 96, 99, 92.

The periodic drying of smaller Plains streams may well be catastrophic to lampreys which spend a protracted, relatively immobile larval life buried in the bottom. To this presumed source of depletion may be added the siltation of suitable gravel spawning beds. With these decimating factors, future collections of lampreys in the middle and upper Missouri basin are apt to be infrequent. Whether on not *Ichthyomyzon castaneus* ranges far upstream in the Missouri must await the examination of additional material, but this may be hard to secure.—REEVE M. BAILEY, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

TRICAINE METHANESULFONATE (M.S. 222) AS AN ANESTHETIC FOR THE SEA LAMPREY, *PETROMYZON MARINUS*.—Tricaine methanesulfonate (M.S.222-Sandoz) has been used extensively since 1920 as a quick anesthetic for immobilizing poikilothermous aquatic vertebrates. Successful application of the anesthetic has been reported for numerous species of three classes, Chondrichthyes, Osteich-

TABLE 1

ANESTHESIA AND RECOVERY TIME OF LAMPREYS IN VARIOUS CONCENTRATIONS OF M.S.222.

| Dosage (g/L) | Weight (grams) | Length (cm.) | Anesthesia and recovery time (minutes:seconds) | | | |
|---|---|---|---|---|---|---|
| | | | Respiration ceased | Muscular movement ceased | Respiration resumed | Muscular movement resumed |
| 0.05 | *119.8* | *40.9* | — | *30:04* | — | *3:05* |
| | (44–209)[1] | (31.5–49.5) | | (5:30–65:10) | | (0:30–6:00) |
| 0.065 | *105.8* | *37.8* | — | *5:50* | — | *5:12* |
| | (57–144) | (32.5–43) | | (3:00–9:00) | | (3:25–7:50) |
| 0.1 | *111.0* | *40.3* | *42:43* | *3:26* | *0:30* | *5:22* |
| | (46–177) | (30.5–47) | (7:50–88:50) | (2:25–4:00) | (0:20–0:45) | (3:00–7:35) |
| 0.25 | *108.1* | *37.9* | *2:29* | *2:45* | *2:14* | *5:36* |
| | (42–211) | (30.5–46.5) | (1:25–3:20) | (1:35–3:25) | (1:05–4:00) | (3:35–6:50) |
| 0.5 | *96.0* | *38.0* | *1:46* | *2:34* | *5:11* | *8:58* |
| | (36–153) | (28–43.5) | (1:20–2:00) | (1:30–4:10) | (3:00–6:10) | (6:00–10:30) |
| 1.0 | *107.6* | *38.8* | *1:33* | *2:29* | *5:40* | *9:30* |
| | (52–158) | (32.5–43) | (1:00–2:00) | (1:20–3:30) | (4:00–8:45) | (7:45–12:15) |
| 2.0 | *126.1* | *40.1* | *1:06* | *1:52* | *7:48* | *11:02* |
| | (62–236) | (33–46.5) | (0:45–1:45) | (1:10–2:45) | (6:15–8:30) | (9:55–11:50) |

[1] Average of six animals in italics; range in parentheses.

thyes, and Amphibia (Anonymous, *Technical Bulletin, Sandoz Pharmaceuticals, Hanover, New Jersey*, 1958). This leaves one aquatic class, Agnatha, for which the use of M.S.222 apparently has never been reported. Such a report is presented here, using the agnathan, *Petromyzon marinus*, the sea lamprey of the Great Lakes.

The animals employed were adult upstream migrants taken in May and June from traps used in connection with the electric screen across the Ocqueoc River which flows into Lake Huron in northern Michigan. The lampreys were held in a raceway supplied with Lake Huron water whose temperature at the time of the experiments was approximately 57 degrees F. Six lampreys were placed in the anesthetic individually at each of seven concentrations ranging from 0.05 to 2.0 grams per liter. Times were determined for cessation of respiratory movements and complete muscular paralysis. Immediately following complete anesthesia, the animals were placed in fresh water and times were determined for recovery of respiratory movements and recovery of muscular coordination as evidenced by vigorous swimming. Jars used for anesthesia contained two liters of Lake Huron water and recovery jars contained five liters. Both were well aerated with compressed air escaping through stone air breakers, and their temperature was maintained by a large water bath at a level not more than one degree higher than that of the raceway water in which the animals were stored. Because of the possibility of weakening of the solution from absorption of the anesthetic by the animals' tissues, no more than three lampreys were anesthetized in any one solution.

Results for each concentration of M.S.222 are shown in Table 1, the means for six animals being italicized and the ranges shown in parentheses below the means. Weights are in grams, lengths in centimeters, and times in minutes:seconds.

Each increase in dosage was accompanied by a reduction in the time required for anesthesia and an increase in recovery time, for both respiratory and muscular activity. At concentrations of .065 g/L and .05 g/L muscular movements were completely stopped, but respiratory movements did not cease even though these two series of animals were kept in the anesthetic for three hours before removal to fresh water. There was not a death at any concentration, so any dosage in the table can be used safely. However, unless the most rapid possible anesthesia is desired, the slight saving in time from the use of higher concentrations would scarcely warrant the use of a concentration greater than .25 g/L. This concentration produces complete anesthesia relatively quickly, followed by relatively rapid recovery. If immobilization is desired with respiratory movements continuing, a concentration of .065 g/L appears ideal. At .1 g/L respiration continued for some time, but invariably stopped eventually, while at .05 g/L respiration continued, but immobilization time averaged about half an hour, and for as much as ninety minutes the animals could be stimulated to move by handling. At .065 g/L immobilization was complete and relatively rapid and recovery was prompt.

The series treated with a concentration of 1.0 g/L was repeated at hourly intervals for a total

of four trials at the same dosage (Table 2). All six animals survived. There was an observable decrease in activity by the end of the trials, but this was not clearly reflected in the data. Although variation in times occurred, no consistent pattern emerged that would demonstrate either more or less rapid response to or recovery from the anesthetic. However, individual differences in response, not shown in the summary table, tended to show consistency throughout the four trials.

TABLE 2

REPEATED ANESTHESIA OF SIX LAMPREYS WITH M.S.222 CONCENTRATION OF 1.0 g/L.

| Trial Number | Anesthesia and recovery time (minutes:seconds) | | | |
|---|---|---|---|---|
| | Respiration ceased | Muscular movement ceased | Respiration resumed | Muscular movement resumed |
| 1 | *1:33* (1:00–2:00)[1] | *2:29* (1:20–3:30) | *5:40* (4:00–8:45) | *9:30* (7:45–12:15) |
| 2 (after 1 hr.) | *1:27* (0:50–2:00) | *2:53* (2:20–3:40) | *7:10* (5:30–10:00) | *11:02* (8:40–13:45) |
| 3 (after 2 hrs.) | *1:40* (1:00–2:10) | *2:52* (1:35–4:30) | *7:46* (5:00–11:25) | *11:44* (8:55–16:10) |
| 4 (after 3 hrs.) | *1:50* (1:20–2:15) | *2:16* (1:50–3:00) | *6:30* (4:15–10:25) | *11:20* (10:00–15:10) |

[1] Average of six animals in italics; range in parentheses.

Within experimental groups there was no consistent evidence of correlation of either size or sex with response to or recovery from the anesthetic.

By virtue of the hardiness of the sea lamprey it would appear that M.S.222 could be adapted to virtually any laboratory use of the animal requiring anesthesia, by judicious adjustment of the dosage and sustained or repeated application of the anesthetic.

This investigation was conducted at the Hammond Bay Fishery Laboratory of the United States Fish and Wildlife Service at Rogers City, Michigan. Appreciation is expressed to Dr. Vernon C. Applegate, Director of the laboratory, and to Dr. James W. Moffett, Chief, Great Lakes Fishery Investigations. M.S.222 for use in the tests was generously supplied by Sandoz Pharmaceuticals, Hanover, New Jersey. The work was done in connection with an investigation of the body fluid compartments of vertebrates supported by United States Public Health Service grant H-3134. This is No. 307, studies from the Department of Zoology, University of Nebraska.—THOMAS B. THORSON, *Department of Zoology, University of Nebraska, Lincoln, Nebraska.*

SLIME PRODUCTION IN *MYXINE GLUTINOSA* LINNAEUS.—*Myxine glutinosa* derives its generic and specific names from its capacity to produce large quantities of slime when disturbed. Linnaeus (*Syst. Nat., ed. 10, p. 650,* 1758) included a reference to the phenomenon: "*aquam in gluten mutat,*" later modified (*Syst. Nat., ed. 12, p. 1080,* 1767) to "*aquam in gluten vertit.*" Couch (*A History of the Fishes of the British Islands, ed. 4, p. 410,* 1878) stated that "A single individual that was placed in a quantity of water equal to three or four cubic feet was found to fill it with slime so entirely that the whole could be lifted out with a stick in a single sheet." Goode and Bean (*U. S. Nat. Mus. Spec. Bull. 3,* 1895) made the more modest claim that "A single hag will fill a two-gallon bucket with slime mingled with water in a few seconds, and after a slight interval can repeat the operation with ease." Cole (*Trans. Roy. Soc. Edinburgh 49: 294,* 1912), commenting upon the above statement, wrote: "Its power of secreting slime has been greatly exaggerated, unless the extensive experience which I have had is greatly at fault." However, Bigelow and Schroeder (*Fishes of the Western North Atlantic, 1: 39,* 1948), referring to the same passage, stated: "... we think this no exaggeration." Thus there exists considerable difference of opinion on a characteristic of some interest.

There is a ten-fold difference between the extreme values of these estimates. One hagfish, according to Couch, can gelatinize some 80–110 liters of water. According to Goode and Bean, an individual can gelatinize 7–8 liters (or possibly less, since "mingled with water" implies incomplete gelatinization). The experiment described below may contribute to a solution of this long-standing disagreement.

In April, 1958, five *Myxine* were collected from Gullmar Fiord, Sweden, by Gustafson's (*Arkiv Zool. 28: 1–8,* 1935) method, whereby the hagfish are trapped in a large bottle containing deep-sea water. The advantage of this technique is that the hagfish are protected from contact with surface water of lower salinity while being hauled to the surface. Within 1–2 hours of capture the hagfish were gently decanted into aquaria in the Kristineberg Zoological Station which were supplied with running deep-sea water (salinity *ca.* 33 ppt., temperature *ca.* 8° C). In the course of trapping and transport, these animals produced negligible amounts of slime, in marked contrast to those collected in baited eel-pots.

Individual hagfish were transferred from the aquaria into a basin containing 1,000 cc. of deep-sea water, in which they were handled and squeezed for fifteen minutes. Two drops of 40%

formaldehyde were then added to the water as a chemical irritant to the skin and the treatment was continued for an additional five minutes. The combined treatments appeared to empty the slime glands, which lost their whitish appearance and became slightly concave.

Slime, as it was produced, was transferred from the basin to a measuring cylinder. It is difficult to assess the volume of slime produced over a period since, as noted by Ferry (*Jour. Biol. Chem. 138: 263–268*, 1941) with respect to the slime of *Eptatretus stouti*, the gelatinous mass begins to contract shortly after it is formed. It might be expected that the volume of slime would be indeterminate, owing to solution in the surrounding water. This is not the case. The slime of *Myxine*, like that of *Eptatretus* (Newby, *Jour. Morph. 78: 397–410*, 1946), is composed of a tangle of discrete microscopic fibers which, unless seriously disturbed, has a definite interface with the surrounding water. Imbibition of water appears to be partly within and partly between the close-packed fibers. Shrinkage of the slime-mass is accompanied by close coiling of the microscopic fibers, indicating a molecular re-orientation within the fibers.

TABLE I

VOLUME AND DRY WEIGHT OF SLIME PRODUCED BY *Myxine glutinosa*

| Length of hagfish (cm.) | Volume of slime (cc.) | Dry weight of slime (g.) | Percentage of solids in washed slime |
|---|---|---|---|
| 32 | 400–500 | 0.35 | 0.08 |
| 33 | 500–600 | 0.40 | 0.07 |
| 33 | 500–600 | 0.45 | 0.08 |
| 34 | 300–450 | 0.20 | 0.06 |
| 35 | 450–550 | 0.35 | 0.07 |
| Mean 33 | 430–540 | 0.35 | 0.07 |

The volumes recorded in Table 1 are expressed as a range, the higher value being the total volume of water and slime in the measuring cylinder at the end of the experiment, the lower being the volume of the slime alone. The slime-mass collected from each animal was allowed to contract for about 2 hours, washed for an additional hour in running tap-water, and dried at 100° C.

A medium-sized European hagfish, subjected to continued severe irritation can produce about 500 cc. of slime. However, this finding does not finally settle the dispute. It may be significant that Cole worked with European *Myxine* whereas Goode and Bean and also Bigelow and Schroeder, worked with North American forms. The possibility exists that there are physiological differences between the populations at the extremes of the geographical range, but it is not necessary to invoke this. *Myxine* from the Western Atlantic grow to about twice the length of those on the European seaboard, so an average North American *Myxine* might be expected to produce between two and eight ($2^3$) times as much slime as the average European individual. If this should prove to be so, all points of view could be reconciled. Couch's claim may be dismissed, if only for the inherent improbability that a man could lift about 100 kg. of slime on the end of a stick.

The concentration of 0.07 percent solid material in the slime is not extraordinary, being similar to that of a gelatine gel.

I am grateful to Dr. Gustafson, Director of the Kristineberg Zoological Station, Fiskebäckskil, Sweden, for providing the facilities which rendered these observations possible.—RONALD STRAHAN, *Department of Zoology, University of Hong Kong, Hong Kong.*

*CYPSELURUS LUETKENI* (JORDAN AND EVERMANN) A SYNONYM OF *CYPSELURUS HETERURUS* (RAFINESQUE)?—Brunn (*Dana Rept. 6: 1–106, 7 pls.*, 1935) revised the Atlantic flying fishes. Breder (*Bull. Bing. Ocean. Coll. 6(5): 1–126*, 1938) published a revision of the same group. Present workers utilize Breder's paper for identification of flying fishes, understandably following a general pattern of acceptance of the most recent revision as the most correct one. It is my purpose to evaluate certain data included in these two revisions and provisionally to resurrect one of the species recognized by Brunn, but placed in synonymy by Breder.

Breder accepted Brunn's classification with the exception that he synonymized Brunn's *Cypselurus luetkeni* and *C. heterurus* under the latter name. It was Breder's opinion that the diagnostic characters (predorsal scales, transverse scales, etc.) used by Brunn to separate these two species were insufficient, and he adequately demonstrated this. Since the appearance of Breder's paper the name *C. luetkeni* has not been used. Both Breder and Brunn, however, failed to note differences between certain proportional characters (see Tables) listed by Brunn in his Tables 39 and 43 for the two species. I have taken the data from these tables and included them below as frequency distributions (rather than as Brunn did by listing proportions for each individual examined). The sizes (135–308 mm.) of the fishes compared are similar and equally distributed.

TABLE 1

HEAD LENGTH AS PERCENT OF STANDARD LENGTH

| | 20.0–20.4 | 20.5–20.9 | 21.0–21.4 | 21.5–21.9 | 22.0–22.4 | 22.5–22.9 | 23.0–23.4 | 23.5–23.9 | 24.0–24.4 | 24.5–24.9 | 25.0–25.4 | 25.5–25.7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. heterurus*, Brunn | 2 | 2 | 2 | 1 | 4[1] | | | | | | | |
| *C. luetkeni*, Brunn | | | | 2[2] | | | 2 | 2 | 3 | 2 | | |
| *C. heterurus*, Breder | | | 1 | | | 1 | | 1 | 1 | 2 | | 2[3] |

TABLE 2

SNOUT LENGTH AS PERCENT OF STANDARD LENGTH

| | 4.6–4.8 | 4.9–5.1 | 5.2–5.4 | 5.5–5.7 | 5.8–6.0 | 6.1–6.3 | 6.4–6.6 | 6.7–6.9 | 7.0–7.2 | 7.3–7.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| *C. heterurus*, Brunn | 1 | 2 | 2 | 4 | 2[1] | | | | | |
| *C. luetkeni*, Brunn | | | | 3 | 2[2] | 4 | 1 | 1 | | |
| *C. heterurus*, Breder | | | | | | 1[3] | 1 | 2 | 2 | 2 |

TABLE 3

DIAMETER OF EYE AS PERCENT OF STANDARD LENGTH

| | 6.0–6.2 | 6.3–6.5 | 6.6–6.8 | 6.9–7.1 | 7.2–7.4 | 7.5–7.7 | 7.8–8.0 | 8.1–8.3 | 9.4 |
|---|---|---|---|---|---|---|---|---|---|
| *C. heterurus*, Brunn | 2 | 2 | 5 | 1[1] | 1 | | | | |
| *C. luetkeni*, Brunn | | 1[2] | | 2 | 1 | 1 | 4 | 2 | |
| *C. heterurus*, Breder | | | | | 1 | 2 | 3 | 1 | 1[3] |

TABLE 4

LENGTH OF PECTORAL AS PERCENT OF STANDARD LENGTH

| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C. heterurus*, Brunn | | | | | | | | 3 | | | 3[1] | 3 | 1 |
| *C. luetkeni*, Brunn | 1 | 1 | | 1 | 3 | | | 2[2] | 2 | 1 | | | |
| *C. heterurus*, Breder | | 1 | 1 | | 2[3] | | 1 | | 2 | | | 1 | |

[1] includes specimen from Bermuda
[2] includes specimen from Ghana
[3] includes holotype of *C. luetkeni*, after Breder

Also included in my tables are data taken from Breeder's Table 15, but only for specimens within the same size range as Brunn's. It can be noted from these tables that there is an overlap between the two species as they were considered by Brunn, but there is also a noticeable degree of separation. The data from Breder's table are closer to those of Brunn's *C. luetkeni* than Brunn's *C. heterurus*.

Those specimens reported by Brunn as *C. heterurus* were all from the eastern Atlantic and Mediterranean with the exception of one from Bermuda, the identification of which he considered doubtful. All specimens he recorded as *C. luetkeni* were from the western Atlantic, except one from the Gold Coast (Ghana), which appears to be extreme in some characters and closer to his *C. heterurus*. All of Breder's specimens were from the western Atlantic.

Two specimens which I recently examined from the west coast of Florida (John's Pass, Madeira Beach, and *Oregon* Station 2166: 26° 37'30", 82°54'30") are well within the limits of Brunn's *C. luetkeni*. With this evidence it appears to me that it is best to follow Brunn and to regard *C. heterurus* (the eastern Atlantic form) and *C. luetkeni* (the western Atlantic form) as distinct.—VICTOR G. SPRINGER, *Florida State Board of Conservation Marine Laboratory, St. Petersburg, Florida. Contribution No. 22.*

# Herpetological Notes

THE RELATION OF THE FALL LINE TO THE DISTRIBUTION AND ABUNDANCE OF TURTLES.—The fall line in the southeastern U. S. divides the older paleozoic and crystalline strata from the cretaceous and more recent coastal plain sediments, and is marked generally by low hills. Rivers flowing across the fall line from the upland to the coastal plain usually have stretches of shoals or rapids. Field work by the Tulane field crews of 1953–1956 suggest that the distribution and abundance of turtles is strongly affected by the different ecological conditions above and below the fall line.

Many turtles other than those listed were taken, but particular emphasis was placed upon collecting *Sternothaerus* and emydid turtles, so only data on these are included. The spelling of the generic name is that of Bell (*Zool. Jour. 2*, 1826) and is revived by the author for reasons given elsewhere (Tinkle, *Tulane Stud. Zool. 6(1)*, 1958). The total catch of each species and the catch per unit effort were noted above and below

TABLE 1

NUMBER OF TURTLES CAUGHT IN THREE MAJOR RIVER DRAINAGES OVER A FOUR-YEAR PERIOD WITH A COMPARISON OF THE CATCH PER UNIT EFFORT IN EACH RIVER ABOVE AND BELOW THE FALL LINE

*S. Sternothaerus; G. Graptemys; P. Pseudemys*

| | Below Fall Line | | | | | | Above Fall Line | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tombigbee | Warrior | Alabama | Flint | Chattahoochee | Totals | Warrior | Coosa | Flint | Chattahoochee | Totals |
| *No. of Trips* | 1 | 5 | 2 | 2 | 1 | 11 | 5 | 3 | 2 | 1 | 11 |
| *No. of Boat Hours* | 3 | 55 | 14 | 20 | 3 | 95 | 36 | 25 | 5 | 2 | 68 |
| *No. of Trap Hours* | 97 | 283 | 78 | 118 | 0 | 576 | 623 | 258 | 109 | 164 | 1154 |
| *Total Catch* | 24 | 570 | 44 | 84 | 5 | 727 | 117 | 115 | 4 | 1 | 237 |
| *S. minor* | 6 | 56 | 1 | 1 | 0 | 64 | 0 | 21 | 0 | 0 | 21 |
| *S. odoratus* | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 28 | 0 | 0 | 31 |
| *S. depressus* | 0 | 0 | 0 | 0 | 0 | 0 | 57 | 0 | 0 | 0 | 57 |
| *G. pulchra* | 12 | 25 | 4 | 0 | 0 | 41 | 7 | 8 | 0 | 0 | 15 |
| *G. barbouri* | 0 | 0 | 0 | 29 | 0 | 29 | 0 | 0 | 0 | 0 | 0 |
| *G. geographica* | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 3 |
| *G. nigrinoda* | 5 | 389 | 13 | 0 | 0 | 407 | 0 | 0 | 0 | 0 | 0 |
| *P. scripta* | 0 | 75 | 23 | 7 | 5 | 110 | 2 | 54 | 0 | 0 | 56 |
| *P. floridana* | 1 | 25 | 3 | 47 | 0 | 76 | 45 | 4 | 4 | 1 | 54 |
| | Tombigbee Drainage | | Alabama Drainage | Apalachicola Drainage | | | Tombigbee | Alabama | Apalachicola | | |
| *No. of Turtles* | 594 | | 44 | 89 | | 727 | 117 | 115 | 5 | | 237 |
| *No. of Catch Hours* | 438 | | 92 | 141 | | 671 | 659 | 283 | 280 | | 1222 |
| *Catch per unit effort* | 1.4 | | 0.5 | 0.6 | | 1.1 | 0.2 | 0.4 | 0.0 | | 0.2 |

the fall line in the Tombigbee, Alabama, and Apalachicola rivers. Trapping and hand collecting by the method of Chaney and Smith (*Copeia 1950 (4): 323–4*) were the techniques used. Because traps are effective for about one-third of the diel cycle, the total trap hours were divided by three to obtain the catch hour unit effort. The hours of hand collecting were added to the trap hours and this total divided by the total catch to obtain the catch per unit effort (Table 1).

These data show that the catch per unit effort below the fall line is 5.5 times that above. There are doubtless many reasons for this, but one of the most important is the absence of suitable nesting sites along the generally rocky streams above the fall line. The bodies of water that are deep and suitable for large numbers of turtles are generally secondarily so because of damming of once clear, rapid-flowing streams. Therefore, conditions may now be favorable for some species, but time since impoundment has not been sufficient for them to establish populations; and unfavorable to others because of the lentic situations created behind the locks and dams and absence of sandbars for nesting. If boat collecting data alone are considered, the catch per unit effort is twice as great below as above (7.7 to 3.5) and trapping data alone show 1.3 turtles per unit effort below, 0.2 above.

There is also a difference in which species occur above and below the fall line (Table 2). *Sternothaerus depressus* occurs only above the fall line; *Graptemys nigrinoda* occurs only below, both in the same river. *Graptemys nigrinoda* is rheophilus and the damming of rivers might have caused its demise behind the dams. On the other hand, this turtle may have evolved on the coastal plain relatively recently and been unable to cross the fall line (Cagle, *Tulane Stud. Zool. 1(11)*, 1954). This last conjecture is most reasonable. The rivers on the piedmont prior to damming were rapid-flowing, rocky streams, for the most part unsuited for the development of large populations of any turtle species. Other species occur in nearly equal abundance above and below the fall line (e.g., *Sternothaerus minor* and *Graptemys pulchra*), but the fact that there are some morphological differences between populations above and below indicates a restriction of gene exchange between them. Of the nine species (Table 2), three occurred only above the fall line, two occurred only below, and four occurred both above and below, albeit often in different proportions.

TABLE 2

PERCENTAGE COMPOSITION OF TURTLE POPULATIONS RELATIVE TO NINE SPECIES IN THREE RIVER SYSTEMS ABOVE AND BELOW THE FALL LINE. ALL FIGURES SHOWN ARE PERCENTAGES

*S. Sternothaerus; G. Graptemys; P. Pseudemys*

| Species | Below Fall Line | | | Above Fall Line | | | Over-all Percentage Composition | |
|---|---|---|---|---|---|---|---|---|
| | Tombigbee | Alabama | Apalachicola | Tombigbee | Alabama | Apalachicola | Below Fall Line | Above Fall Line |
| *S. minor* | 10 | 2 | 1 | 0 | 18 | 0 | 9 | 9 |
| *S. odoratus* | 0 | 0 | 0 | 3 | 24 | 0 | 0 | 13 |
| *S. depressus* | 0 | 0 | 0 | 49 | 0 | 0 | 0 | 24 |
| *G. pulchra* | 6 | 9 | 0 | 6 | 7 | 0 | 6 | 6 |
| *G. barbouri* | 0 | 0 | 33 | 0 | 0 | 0 | 4 | 0 |
| *G. geographica* | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 1 |
| *G. nigrinoda* | 66 | 30 | 0 | 0 | 0 | 0 | 56 | 0 |
| *P. scripta* | 13 | 52 | 13 | 1 | 47 | 0 | 15 | 24 |
| *P. floridana* | 4 | 7 | 53 | 38 | 3 | 100 | 10 | 22 |

The fall line marks the limits of distribution of some turtles in one river, but not in another. *Sternothaerus minor peltifer* occurs only below the fall line in the Tombigbee River, but is found above and below in the Alabama. This, with other evidence, suggests that this form originated above the fall line (Tinkle, *op. cit.*). *Pseudemys scripta*, taken above and below the fall line in the Alabama River, is rare above the fall line in the Tombigbee and absent in the Apalachicola above the fall line.

These data contain some inherent errors because they include results of trips during which rivers were worked in different years or at different times during the same year. Some rivers were not worked as often, as long, or as intensively as others. The most extensive data are those obtained in the Tombigbee River of Alabama over a four-year period which are treated in detail (Table 3). Only those trips are included when there was a lapse of one week or less between visits above and below the fall line. These data substantiate the previous findings that the catch per unit effort is always greater below than above the fall line. The least difference is two and one-half to one, the greatest 35 to one, and the over-all four-year difference is 10 to one.

TABLE 3

RELATIVE ABUNDANCE OF TURTLES IN THE TOMBIGBEE RIVER OF ALABAMA ABOVE AND BELOW THE FALL LINE OVER A FOUR-YEAR PERIOD

*S. Sternothaerus; G. Graptemys; P. Pseudemys*

| | Above | Below | Above | Below | Above | Below | Above | Below | Total Above | Total Below |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | | 1954 | | 1955 | | 1956 | | | |
| | 17–18 June | 19 June | 17–19 Aug. | 14–16 Aug. | 9–13 Aug. | 17–19 Aug. | 10–12 July | 12–15 July | | |
| *S. minor* | 0, — | 9, 12% | 0, — | 6, 6% | 0, — | 13, 17% | 0, — | 24, 13% | 0, — | 52, 12% |
| *S. odoratus* | 2, 6% | 0, — | 0, — | 0, — | 1, 4% | 0, — | 0, — | 0, — | 3, 3% | 0, — |
| *S. depressus* | 14, 41% | 0, — | 8, 42% | 0, — | 14, 54% | 0, — | 6, 67% | 0, — | 42, 48% | 0, — |
| *G. pulchra* | 2, 6% | 1, 1% | 1, 5% | 11, 10% | 3, 12% | 6, 8% | 0, — | 3, 2% | 6, 7% | 21, 5% |
| *G. geographica* | 2, 6% | 0, — | 0, — | 0, — | 0, — | 0, — | 0, — | 0, — | 2, 2% | 0, — |
| *G. nigrinoda* | 0, — | 52, 71% | 0, — | 76, 70% | 0, — | 47, 61% | 0, — | 129, 69% | 0, — | 304, 68% |
| *P. scripta* | 0, — | 9, 12% | 0, — | 8, 7% | 1, 4% | 9, 12% | 1, 11% | 25, 13% | 2, 2% | 51, 11% |
| *P. floridana* | 14, 41% | 2, 3% | 10, 53% | 8, 7% | 7, 27% | 2, 3% | 2, 22% | 5, 3% | 33, 38% | 17, 4% |
| *Total Catch* | 34 | 73 | 19 | 109 | 26 | 77 | 9 | 186 | 88 | 445 |
| *Trap Hours* | 0 | 0 | 153 | 53 | 201 | 130 | 243 | 107 | 597 | 290 |
| *Boat Hours* | 9 | 7 | 9 | 8 | 7 | 9 | 4 | 7 | 29 | 31 |
| *Catch Hours* | 9 | 7 | 162 | 61 | 208 | 139 | 247 | 114 | 626 | 321 |
| *Catch/Unit Effort* | 3.8 | 10.4 | .1 | 1.8 | .1 | .6 | .0 | 1.6 | .14 | 1.4 |

Almost every year was abnormal in some respect. The comparatively high catches per unit effort of 1953 were due to the fact that traps were not used that year. The employment of one to two dozen traps greatly increases the number of catch hours without adding a compensatory catch. Excepting the years 1953 and 1955, the catch per unit effort remains remarkably constant below the fall line. The low figure of 1955 was due to the fact that the river was low, leaving most of the brush piles from which turtles are normally taken above the water level. Above the fall line, the catch per unit effort is also fairly constant. The two exceptional years are 1953, which has already been explained, and 1956 when the river was so muddy that hand-collecting was difficult.

Of the eight turtle species in the Tombigbee, two occur only below the fall line, three only above, and three occur both above and below. *Graptemys pulchra* occurs in nearly the same relative abundance above and below the fall line, although it is numerically more common below. *Pseudemys scripta* is more common below the fall line, whereas *Pseudemys floridana* is more common above; both occur above and below. The environment in the Tombigbee River below the fall line is lotic with numerous brush piles and sandbars generally favorable to the development of large turtle populations. The environment above the fall line is lentic and often rocky with very few sandbars and much brush.

The fall of the Tombigbee River below and above the fall line is similar to that of other Alabama rivers originating above the paleozoic-cretaceous contact. From a height of 181 feet above mean low tide level (Mobile) at lock 17, this river falls 91 feet in the 26 miles to Tuscaloosa on the fall line. This is a fall of 3.5 feet per mile. From Tuscaloosa to a point 180 miles downstream where the river drops to the level of mean low tide (Mobile), the Tombigbee falls but 70 feet. This is a fall of 0.4 feet per mile over the coastal plains (Hall and Hall, *Geol. Surv. of Ala. Bull. 17*, 1916). However, on most Alabama rivers locks and dams so reduce the flow above the fall line that conditions are secondarily lentic whereas the coastal plain streams may exhibit slightly more current.

Further collecting may reveal imperfections in these data because relatively few localities on any single river were studied, but these observations show that the fall line or conditions indirectly related to it are of importance in the distribution of turtles in the southeastern U. S.—DONALD W. TINKLE, *Department of Biology, Texas Technological College, Lubbock, Texas.*

AMPHIBIANS AND REPTILES OF THE THOUSAND ISLANDS REGION, NEW YORK.—The Thousand Islands consist of about 1,700 islands in the headwaters of the St. Lawrence River as it flows northeastward out of Lake Ontario toward the Atlantic Ocean. From December 1952 to June 1954 a study was made of ten of these islands and the adjacent mainland to determine the distribution of the amphibians and reptiles and to investigate the effects of isolation on the populations. The study islands, Belle, Douglas, Florence, Harbor, Ironsides, Iroquois, Kipp, Welcome, Wellesley, and Whiskey extend along the river for 10 miles within the limits of 44°16′ to 44°24′ north latitude and 76°04′ to 75°48′ west longitude. I am indebted to Professor W. J. Hamilton, Jr. of Cornell University, who advised me throughout the study.

The islands studied range in size from less than an acre to over 8,000 acres. A few of the larger islands have ponds and streams, but most of the small ones lack these. The shorelines, mostly rocky, are unsuited for amphibian breeding. The natural vegetation is oak-hickory, or maple-beech-hemlock forest. On severely disturbed islands grass or weeds and shrubs may be the dominant vegetation. Topsoil is in general thin, and rock outcrop is common. Greater detail on vegetation, size, and degree of isolation is given elsewhere (Werner, *Jour. Mammalogy, 37: 395–406*, 1956).

Results indicated that none of the islands is sufficiently isolated from another or from the mainland to have any effect on the evolution of the populations considered. The small size of many of the islands is probably restrictive as to species present through the effect of size on the lack of suitable habitat, especially amphibian breeding ponds.

Stomach analyses were made on all species to provide more accurate distribution records as well as to gain an idea of food habits. *Ambystoma maculatum* was recorded from only one island as the result of its recovery from the stomach of a garter snake. Stomach analyses also showed that *Thamnophis sirtalis* will feed on meadow mice, *Microtus pennsylvanicus*.

*Necturus maculosus maculosus* Rafinesque.—Taken from stomachs of *Natrix s. sipedon*; apparently the mudpuppies were captured in the St. Lawrence River.

*Diemictylus viridescens viridescens* Rafinesque.—Red-spotted newts were collected only on the mainland in woodland ponds, and the red efts only in the surrounding forest in situations where *Hemidactylium scutatum* and *Plethodon c. cinereus* were also found.

*Ambystoma jeffersonianum* Green.—Mainland only. Five females measured 117, 180, 102, 102, 117 mm. long. Another female with regenerating tail was 72 mm. from snout to vent. According to Minton (*Herpetologica 10: 173–179*, 1954) specimens from this area may be *A. jeffersonianum* X *laterale* hybrids, manifesting the "Clanton effect." The specimens collected may be such hybrids, since all of them were females and were dark blue with light spots instead of gray or brown with light flecks. All of the specimens except the one with the regenerating tail contained large ova. Bishop (*N. Y. State Mus. Bull. 324: 90*, 1941) believed that small size at breeding may be characteristic of a taxonomically distinct form in this general region.

*Ambystoma maculatum* Shaw.—One adult was collected on the mainland and another was removed from the stomach of a garter snake on Ironsides. Ponds suitable for breeding exist on this remote 18-acre island.

*Hemidactylium scutatum* Schlegel.—Only on mainland in beech-maple-hemlock woods along stream and in open clearings under bark of fallen trees. Bishop (*ibid.*: 195) gives a locality record for this species from the "Thousand Islands."

*Plethodon cinereus cinereus* Green.—Douglas and Wellesley and mainland. Since Douglas is one of the smaller and more remote islands, this species may reach all the other islands.

*Bufo terrestris americanus* Holbrook.—Only two specimens taken, both on mainland.

*Pseudacris nigrita triseriata* Wied.—Common on mainland in meadow and woodland ponds and streams; not found on islands.

*Hyla crucifer crucifer* Wied.—Mainland only; more abundant than preceeding and found also in meadow and woodland ponds.

*Hyla versicolor versicolor* LeConte.—Mainland, commonly in woodland situations; heard on Wellesley, which is over 8,000 acres in area. Toner and de St. Remy (*Copeia 1941 (1): 12*) reported it on Hay Island in this general area.

*Rana catesbeiana* Shaw.—Wellesley and Iroquois as well as mainland. Only the wave-washed rocky shorelines might keep the bullfrog from inhabiting any island of the region.

*Rana clamitans melanota* (Rafinesque).—Harbor, Ironsides, Iroquois, Kipp, Wellesley, and mainland. In this area it usually has black spots on the back, whereas Wright and Wright (*Handbook of Frogs and Toads, 3rd. ed., p. 450*, 1949) state that this frog only occasionally has black spots on its back.

*Rana palustris* LeConte.—Mainland only, where it was abundant in but one situation.

*Rana pipiens pipiens* Schreber.—Belle, Florence, Ironsides, Kipp, Welcome, Wellesley, and mainland. The presence of only large adults on Belle, Florence, Kipp, and Welcome suggests that these frogs were either transients or had been unable to breed for several years. Since these islands are not remote from large islands and since they do not have suitable breeding areas, their frogs probably are not permanent residents. Ponds do exist on Ironsides, and juveniles and adults were taken in them. An old egg mass, probably that of *Rana pipiens*, was also found on the island.

*Rana sylvatica sylvatica* LeConte.—Abundant in a maple-beech forest near ponds and in a swampy area on mainland.

*Chelydra serpentina serpentina* Linnaeus.—Wellesley and mainland.

*Sternothaerus odoratus* Latreille.—Wellesley only. Conant (*Field Guide Rept. Amphib., map 7*, 1958) shows the range of the stinkpot as extending across the St. Lawrence River in the region of the Thousand Islands.

*Emydoidea blandingi* Holbrook.—Wellesley and mainland only. Toner (*Copeia 1936 (4): 236*) made note of this turtle on Niagra, Thousand Islands.

*Terrapene carolina carolina* Linnaeus.—A single specimen on Ironsides in a temporary pond. This 18-acre island lies about 1,900 feet from the mainland. Conant (*ibid.: map 28*) indicates the northern range of the eastern box turtle is about 200 miles south of the Thousand Islands,

*Graptemys geographica* Le Sueur.—Wellesley Island only. Toner (*ibid.: 237*) lists it from Float Island, Thousand Islands.

*Chrysemys picta marginata* Agassiz.—Although collected only on Wellesley Island and the mainland, this is the most common turtle of the area. One specimen exhibited kyphosis, whereas another had an abnormally high number of dorsal laminae; five laterals on the right side, and nine centrals. This specimen laid eggs in captivity, two of which hatched and had abnormal numbers of laminae.

*Opheodrys vernalis vernalis* Harlan.—One on Ironsides, and one observed on Wellesley.

*Elaphe obsoleta obsoleta* Say.—A single specimen DOR on Wellesley. Toner (*Copeia 1935 (1): 42*) states that this snake is common in Canada in Leeds County, which borders the St. Lawrence in this region, and that it has been seen on the islands of the river.

*Lampropeltis doliata triangulum* Lacépède.—Wellesley Island and mainland. Hatt *et al.* (*Cranbrook Inst. Sci. Bull. 27: 68*, 1948) found this species on several of the larger islands of Lake

Michigan, indicating that its powers of dispersal are good.

*Natrix sipedon sipedon* Linnaeus.—Without a doubt this is one of the most abundant snakes of the region: Belle, Florence, Ironsides, Welcome, and Wellesley and the mainland; seen on Harbor, Kipp, and Iroquois. See *Necturus m. maculosus* above.

*Storeria dekayi dekayi* Holbrook.—Wellesley and mainland. Toner (*op. cit.:43*) found it on Hay Island in this vicinity.

*Thamnophis sauritus sauritus* Linnaeus.—Wellesley and mainland. Conant (*ibid.:map 102*) shows the range of the eastern ribbon snake on the Canadian mainland in the vicinity of the Thousand Islands.

*Thamnophis sirtalis sirtalis* Linnaeus.—This is the most frequently encountered snake: Belle, Harbor, Iroquois, Ironsides, and Wellesley and mainland. The single specimen collected on Belle may have been a transient, since this island does not seem large enough to support a population. This specimen had eaten a meadow mouse, *Microtus pennsylvanicus*, perhaps an indication of the abundance of this food item. Another one on Ironsides had consumed a specimen of *Ambystoma maculatum*.—WILLIAM E. WERNER, JR. *Biology Department, Blackburn College, Carlinville, Illinois.*

NEW LOCALITIES FOR *LICHANURA ROSEOFUSCA GRACIA* IN INYO COUNTY, CALIFORNIA.—Klauber (*Trans. San Diego Soc. Nat. Hist. 6: 305–318*, 1931), in describing the new subspecies, *Lichanura roseofusca gracia*, reported specimens from three localities in San Bernardino County, and from Randsburg, Kern County, California. The latter record represented the northern limit of distribution of this snake.

The desert rosy boa is known from three localities in Inyo County, California. These records extend the range about seventy-five miles north of the type locality at Randsburg. On April 14, 1951, Carl Hubbs and Karl Lagler collected an adult male in Emigrant Canyon in the vicinity of Emigrant Spring in Death Valley National Monument (SDSNH 41203). On April 5, 1955, I collected an adult female in Hanaupah Canyon, Death Valley National Monument (UCMVZ 64113). This locality is in the vicinity of Hanaupah Springs where, owing to the year-round flow of water, an isolated community of willow and wild-grape, typical of permanent springs in the Panamint Mountains, occurs. The snake was found on the north side of the main fork of Hanaupah Canyon, at an elevation of approximately 3,800 feet, and above the riparian community in a rocky area sparsely grown with *Larrea divaricata*. The boa regurgitated the partially digested carcass of a woodrat (*Neotoma lepida*) on April 6. On June 8 and 9, 1956, James Anderson and John Burns collected four desert rosy boas in Homewood Canyon in the Argus Mountains, about eight miles north of Trona, California (UCMVZ 65737, 65738, 65755, and 65758).

I have examined four of the six specimens from Inyo County and find them to be typical with respect to those features of lepidosis and pigmentation summarized by Klauber (*op. cit.*).

While the range extension indicated by these localities is not great, the occurrence of the desert rosy boa in the Argus and Panamint Mountains, at elevations where there is some snowfall, suggests that we may expect to find boas in the Cottonwood Mountains northwest of Death Valley, perhaps farther north into the Inyo Mountains and Last Chance Range in northern Inyo County. Possibly the desert rosy boa even occurs in parts of southern Esmeralda County, Nevada.—FREDERICK B. TURNER, *Department of Biology, Wayne State University, Detroit, Michigan. Contribution No. 22 from the Department of Biology, Wayne State University.*

*XANTUSIA V. VIGILIS* IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA.—Death Valley National Monument lies within that area recognized as the geographic range of *Xantusia v. vigilis* (Stebbins, *Amer. Midl. Nat. 39: 96–101*, 1948; Savage, *Amer. Midl. Nat. 48: 467–479*, 1951) but the suspected occurrence of the yucca night lizard in this portion of Inyo County has been based only on inferences which could be drawn from known localities in the Inyo Mountains, California, in southwestern Clark County, Nevada, (Klauber, *Trans. San Diego Soc. Nat. Hist. 7: 1–16*, 1931) and in southern Nye County, Nevada (Banta, *Herpetologica 6: 34*, 1950). The distribution of *Xantusia* throughout this area is apparently discontinuous—basins such as Death Valley, Panamint Valley, and Searles Lake Valley almost certainly are not inhabited by these lizards. However, at least some of the various mountain ranges which dissect Inyo County afford suitable habitat for the yucca night lizard. There has been no report of *Xantusia v. vigilis* in the Amargosa Range (to the east of Death Valley) or in the Panamint Mountains, which lie along the west side of the valley.

On April 1, 1954, I found the first of what was eventually to become a series of *Xantusia* about ½ mile above Thorndyke's Ranch in Wild Rose Canyon at an elevation of about 7,800 feet on the west flank of the Panamint Mountains. On April 29, 1955, Robert C. Stebbins, James D. Anderson, and I collected seven more night lizards near

Mahogany Flat on the crest of the Panamints at an elevation of about 8,500 feet. On June 19, and 20, 1955, four additional *Xantusia vigilis* were collected in the Panamints near Rogers Peak by Stebbins and Joe Gorman.

All specimens were taken under fairly uniform conditions. The vegetation at these elevations is piñon pine (*Pinus monophylla*), juniper (*Juniperus osteosperma*), mountain mahogany (*Cercocarpus ledifolius*), some sagebrush (*Artemisia* sp.), and Mormon tea (*Ephedra viridis*). The substrate varies from talus to a thick duff. There are scattered rocks and the lizards were all beneath stones, especially (at least near Mahogany Flat) within or near the root systems of the sagebrush. The mature adults from the Panamint Mountains are all of near maximal size for *Xantusia vigilis* (i.e. males 38–44 mm.; females 42–45 mm. in snout-vent length).

Four *Xantusia* have also been collected from the Amargosa Range on the east side of Death Valley, all from beneath boards. One was found near Dante's View during May of 1954 at about 5,500 feet, one at Greenwater (4,280 feet) and another at Furnace (5,000 feet) on March 23, 1955, (the last two localities are old copper-mining ghost towns). In these three localities (on the east side of the Amargosas) the vegetation is exclusively xerophytic shrubs, especially *Glossopetalon spinescens, Thamnosma montana, Atriplex* spp., and occasionally *Chrysothamnus* sp. The fourth specimen from the Amargosa Range was taken in Monarch Canyon in the Funeral Mountains, at an elevation of 2,960 feet, on April 18, 1955. Here there is *Glossopetalon spinescens, Lycium* sp., and *Chrysothamnus* sp.

All specimens from Death Valley National Monument are typical of *Xantusia v. vigilis* in the number of transverse ventral scale rows (27–30) and in the number of lamellae beneath the fourth toe (19–21) and fourth finger (13–16).—FREDERICK B. TURNER, *Department of Biology, Wayne State University, Detroit, Michigan. Contribution No. 21 from the Department of Biology, Wayne State University.*

A STUDY OF MOVEMENT OF AMERICAN TOADS IN A MINNESOTA BOG.—A study of the movements of American toads (*Bufo terrestris americanus*) was made in Itasca State Park, Minnesota, during the summers of 1954, 1955, and 1956. The work was done in an extensive peat bog extending northward and eastward from the shores of Lake Itasca, the source of the Mississippi River.

The study area, also used in a project on the wood frog (Bellis, *in press*), consisted of a square measuring 120 yards on a side and marked off in the form of a grid of 100 quadrats by means of wooden stakes placed at 12-yard intervals. The dominant overstory tree of the northern, wetter half of the study area was the tamarack (*Larix laricina*); it was underlain primarily by wild calla (*Calla palustris*) and many other marsh species which thrived in a viscous, mucky substrate. Hummocks formed by the tamarack roots stood above the surrounding bog and were covered with small herbaceous plants, principally sedges. The southern half of the study area was shaded primarily by an overstory of black spruce (*Picea mariana*) and an understory of shrubby species, principally speckled alder (*Alnus rugosa*). Here the substrate was covered by mosses, liverworts, and herbaceous groups such as grasses, sedges, and heaths. Fallen trees in various stages of decay and the upturned root systems of trees felled by the wind were in evidence everywhere. Standing water formed small pools in the spruce area and covered all of the tamarack area in 1954 but, except for brief periods following heavy rains, the areas were devoid of standing water in 1955 and 1956. Although captures were made in both typical tamarack and typical spruce habitats, the majority of the toads were found in a zone of transition between the two.

Toads were captured and marked during July, August, and September of 1954; June, July, and August of 1955; and June and July of 1956. Each toad was captured by hand, measured, marked (unless it was a recapture), recorded, and released at the capture site. Numbered stakes served as references to the points of capture. Individuals were marked by toe clipping; the system used was the same as that used by Martof (*Ecology, 34(1): 165–174*, 1953).

Sixty-one individuals were marked and 118 captures were made. Thirty-two were captured once; seventeen, twice; four, three times; three, four times; four, five times; and one, eight times. All captures of each individual taken more than once were made in the same summer when marked except one which was first captured in 1954 and recaptured in 1955. The large number of recaptures suggests that the toads remained in some sort of "home area," at least during the summer months. A more detailed analysis is in order.

The distances between the first and second capture points for individuals captured two or more times were determined. Distances between two capture points established on the same day were not measured as it was thought that the toad required at least one day to "readjust" after being handled and marked. The mean distance is 14.44 yards for 27 individuals, the mode is 10 yards and the median is 10.1 yards. The low value

of the median, which is probably the most useful measure of central tendency in this case, suggests that most of the toads remained in a restricted area during the summer. Eight of the 27 individuals showed between-capture distances of five yards or less, three of them measuring only one yard. The higher values (28, 35, 40, 41, and 44 yards) may represent toads which either strayed from the home area or possibly occupied large areas of the bog. There was no relationship between the size of the toad (body length) and the distance between successive capture points.

Further evidence for the existence of a home range comes through a comparison of the distance between the first and second capture points and the distance between the first and last capture points of toads taken three or more times. In seven cases the first to second capture distances are smaller than the first to last capture distances; but in five cases the first to last capture distances are smaller than the first to second capture distances.

The distances between successive capture points were divided by the corresponding number of days that elapsed between the captures in order to determine the relative movement on a daily basis. The minimum value is .20 yards per day (two yards per ten days and one yard per five days) and the maximum value is 20 yards per day (40 yards per two days). The mean distance for the 27 toads is 4.08 yards per day. It is necessary to add that these values do not represent the actual distances that the toads moved between captures but rather the "minimum" movement possible between capture points; however, they are collectively useful in establishing the relative mobility of the animal.

Carpenter (*Copeia 1954 (3): 197–200*) established a mean value of 2.17 yards per day for the northwestern toad (*Bufo b. boreas*) in the Jackson Hole Wildlife Park, Wyoming. The higher value for the American toads suggests either that they inherently occupy a larger home range than the northwestern toads or that the Lake Itasca bog furnishes less food on a areal basis than the Jackson Hole streamside area studied by Carpenter.

Due to the lack of captures in successive years, probably the result of a high mortality rate, it is not known whether or not the toads generally return to the home area after movements to the breeding sites on the uplands. A distance of 79 yards separated the capture sites of the only individual captured in two summers.—EDWARD D. BELLIS, *Department of Zoology and Entomology, The Pennsylvania State University, University Park, Pennsylvania.*

STUDIES ON THE ORIENTATION OF TURTLES.—Investigations in 1956 indicate that eastern box turtles (*Terrapene c. carolina* Linnaeus) walk in the homeward direction when taken into unfamiliar territory but that such orientation does not occur under overcast skies (Gould, *Biol. Bull. 112 (3): 336–348*, 1957). During 1957, additional observations, reported herein, at Edgewood and Laurel, Maryland, confirmed the ability of some box turtles to exhibit Type III orientation, defined as the choice of approximately the correct direction of its home when an animal is carried into unfamiliar territory in a new and unaccustomed direction (Griffin, *Biol. Rev. 27 (4): 360–393*, 1952). Other experiments demonstrated a similar ability among eastern painted turtles, *Chrysemys p. picta* (Schneider).

I am indebted to George Fletcher and Richard Vogl for their help in the field and to Lucille F. Stickel for collecting box turtles for which she had determined the home range. I wish to thank Mr. Arnold L. Nelson, Director of the Patuxent Research Refuge, for use of the facilities of the station. I acknowledge my thanks to Paul K. Anderson and Fred R. Cagle for suggestions and improvements in the manuscript. I am particularly grateful to Donald R. Griffin for his encouragement and help in the analysis and presentation of the data.

*Methods.*—Procedures for releasing and observing turtles were the same as those employed in the previous year (Gould, *op. cit.*). Several of the release points used in 1956 were utilized and the same criteria for selecting new release points were applied. Painted turtles were trapped in a shallow, impounded pond, Watson Creek, along the east bank of the Gunpowder River in Edgewood (Fig. 1). The pond is about 0.8 miles long by 0.4 miles wide. The turtles may occupy a home range which includes parts or all of adjacent water bodies (Cagle, *Misc. Publ. Mus. Zool, Univ. Mich., No. 61: 1–34*, 1944). The home of all painted turtles was considered to be the center of Watson Creek, very close to the trapping site. It seems unlikely, because of the great overland distances, fences, buildings, roads and woods, that any of the release points other than M Field might have been in familiar territory.

Box turtles were also picked up in the local Edgewood area in addition to those collected at Patuxent by Dr. Stickel.

When a turtle had walked approximately 125 feet from the release point I would often carry it back to the release point and again observe and record its headings. Each such observation is considered an individual release. All the observations were made in unfamiliar territory and under clear skies.

*Results.*—Fifty-three painted turtles were taken in closed containers to at least one release point, and 28 headed within 30 degrees of the homeward direction on the first trial. These 28 were taken from two different directions and 19 of them headed homeward. Eight of these 19 were selected as promising and released several times from at least three release points having different homeward directions (Fig. 1). All of the headings of any one turtle in Figure 1 represent observations made on single days except for the releases of No. 1 and No. 3 from H Field. The following deviations left and right of the homeward direction were recorded: No. 1: 10 June, 30° R; 11 June, 155° R; 12 June, 67° R, 10° R. No. 3: 10 June, 23° L; 11 June, 155° R; 12 June, 33° L.

Box turtles were selected in a similar manner. However, poor weather conditions and lack of time curtailed observations of some turtles which headed correctly on the first trial, so that only a portion were observed from a second direction. All those released in three different directions have been included in Table I.

*Discussion.*—Four of the box turtles had been collected on Patuxent Refuge in previous years in the same general localities as in 1957, so there is assurance that they were taken in their home areas. Dr. Stickel provided the following data on collection localities. One turtle, adult female, No. 52, had been collected often enough that the size of her home range can be estimated. Seventeen collections in eight different years, 1944–1957, were within a distance of 700 feet. This same turtle was collected on an egg-laying trip outside her regular range, nearly ½ mile from the most distant part of her range. The other three were collected less often. Over-all distances between collection points, including the 1957 collection, were: 265 feet for adult female No. 31 (two collections in 1949), 200 feet for a subadult male No. 38 (one collection in 1949), and 580 feet for adult female No. 27 (four collections in 1945). In addition, turtle No. 27 also was collected in 1953 on an egg-laying trip, making a total travel distance of ⅜ mile. These records are in accordance with previously determined ranges of box turtles in this habitat. Stickel (*Ecol. Monog. 20(4): 351–378,* 1950) estimated home ranges of adult box turtles in a single year to be from 100 to 750 feet, with an average of 330 feet (males) or 370 feet (females). Egg-laying trips up to ½ mile also were recorded.

Number 23 (Table I) had been released from two different directions during the previous season (for details see earlier paper). In 1957, No. 23 was recaptured in the same place it was released in 1956 and taken to three other release points. Both season's data are in Table I.

A significant recovery of a painted turtle on its way home was recorded one mile south of

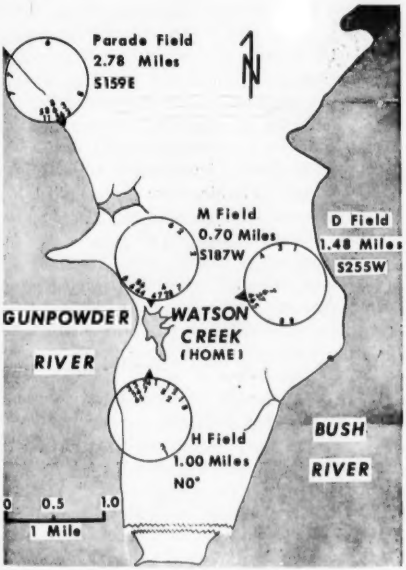



Fig. 1.—Type III orientation in eight *Chrysemys picta.* Each number of a turtle represents one heading. The map is a rough drawing but the distances from the release points (center of each large circle) to the nearest water and to the home, Watson Creek, are drawn to scale. The size of the circles has no relation to the release points.

TABLE I

TYPE III ORIENTATION IN *Terrapene carolina*

Correct headings are within 30 degrees of the homeward direction. The first three were from Edgewood and the last four from Patuxent. Random orientation would result in only one sixth of the headings being this accurate.

| Turtle number | Number of release points | Number of days tested | Number of releases | Number of correct headings | Homeward bearing from each release point (degrees) |
|---|---|---|---|---|---|
| 0–2, 9 | 3 | 3 | 3 | 3 | 145, 186, 347 |
| 0–2, 8 | 4 | 5 | 7 | 4 | 139, 245, 346, 343 |
| 23 | 5 | 5 | 9 | 5 | 220, 210, 163, 235, 3 |
| 31 | 3 | 3 | 5 | 4 | 332, 90, 204 |
| 38 | 3 | 4 | 7 | 3 | 87, 336, 223 |
| 27 | 3 | 3 | 8 | 4 | 85, 333, 224 |
| 52 | 4 | 3 | 5 | 3 | 288, 158, 2 |
| | | | Total 44 | Total 26 | |

home (not included in Fig. 1). It was found 6½ days after release 0.42 miles north of the release point; and it was heading almost directly toward the place it was captured (about five degrees off from the actual homeward direction). The turtle was observed walking in that direction for about 50 yards. The woods between the release point and home were dense, with thickets, ditches, and many overturned trees.

In several instances poor homeward headings of both box and painted turtles appeared to be Type II orientation, in which an animal heads in a particular direction from unfamiliar territory regardless of the homeward direction (Griffin, *op. cit.*). In the case of the turtles, it was a direction which closely resembled a heading taken at a previous release point for a different homeward direction. Similar actions of homing pigeons have been observed by Pratt and Thouless (*Jour. Exp. Biol. 32 (1): 140–157*, 1955).

*Summary.*—Eight painted turtles and seven box turtles selected for their ability to orient homeward were released several times in unfamiliar territory and under clear skies, from at least three, and in some cases as many as five, different homeward directions and at distances ranging from 2.78 miles to 0.1 miles from home. In the case of box turtles, 26 out of 44 headings; and in the case of painted turtles, 40 out of 58 headings were within 30 degrees of the homeward bearing. These data support the hypothesis that turtles can orient from new and different homeward directions when taken into unfamiliar territory.—EDWIN GOULD, *Department of Zoology, Tulane University, New Orleans, Louisiana.*

AN INSTANCE OF BLOOD-SQUIRTING BY *PHRYNOSOMA SOLARE*.—Blood - squirting from the eyes of certain species of horned lizards (genus *Phrynosoma*) is a well-publicized phenomenon. There is no mention in the literature, however, of this defensive mechanism being employed by *Phrynosoma solare*. Briefly, the mechanics of the blood-squirting process are: a special muscle (common to most reptiles) constricts the internal jugular vein, submitting the blood supply in the head to pressure; a muscle under the orbit contracts, increasing the pressure upon a large sinus about the orbit; the nictitating membrane is ruptured, thus permitting the escape of blood. The blood supply in the head is under considerable pressure, as evidenced by the fact that blood can be squirted several feet.

On July 23, 1958, I caught an adult female of this species two miles west of Guadalupe (near Phoenix), Maricopa County, Arizona, and observed the lizard squirt blood four times. The details of this incident are as follows. I was holding the lizard in my hand and had just grasped the head with my thumb and forefinger. Blood was squirted from the left eye; enough blood to cover the finger holding the head. I was startled by the sudden appearance of blood and released the head, which I immediately regrasped. Again, blood was squirted from the left eye. I rubbed the top of the head and blood was squirted from the right eye. Seven hours after the capture of the lizard, I grasped the head in the manner described above, and blood was squirted from the left eye. The lizard was motionless during the squirtings; there was an audible noise (*not* vocal) on each instance of squirting; on each occasion, the direction of the blood was posterior and medially; both eyes were closed during the squirtings. A considerable amount of blood was squirted. I would estimate, at least, two cubic centimeters.—WILLIAM L. CUTTER, *U. S. Public Health Service, CDC-Phoenix Field Station, Phoenix, Arizona.*

BLOOD PROTEIN AND MINERAL CHEMISTRY IN FROG RED LEG DISEASE.—Red leg disease of frogs is a hemolytic septicemia. The study of the affected blood has been the subject of previous investigations (Kaplan, *Proc. Animal Care Panel 3: 74–92*, 1953). Because of the considerable economic and laboratory value of the frog, it was considered important to investigate certain biochemical changes in its serum during the acute phases of this highly prevalent disease.

Total serum proteins, individual protein fractions, and the non-protein nitrogen (NPN) wastes are often significantly altered in disease; these were analyzed. The inorganic ions, sodium, potassium and chloride, were also studied because they are assuming considerable importance in blood diseases (Moore, *N. E. Jour. Med. 258: 277–85*, 1958).

*Materials and methods.—Rana pipiens*, obtained commercially, was used exclusively. All frogs were held unfed at 6° C. in plastic containers. No determinations were made prior to storage for one week.

Frogs which showed no characteristic evidence of red leg infection, as determined externally and by occasional blood smears, were used as "normal" controls. Diseased frogs had been previously naturally infected or else they were injected through the dorsal lymph sac with 0.6 percent saline washes containing graded concentrations of *Pseudomonas hydrophila*, the causal organism, grown on sterile agar slants. The bacterial concentrations were only relatively determined.

To minimize extraneous body fluids, blood was obtained by direct cardiac puncture. Anticoagulants were avoided so that undiluted serum

TABLE I

SERUM PROTEIN AND MINERAL CHANGES IN FROG RED LEG DISEASE

| | Normal | | | Diseased | | | P value |
|---|---|---|---|---|---|---|---|
| | Number of determinations (samples)[1] | Mean | S.D. | Number of determinations | Mean | S.D. | |
| Proteins (g./100 ml.) | | | | | | | |
| Total protein (biuret) | 50 | 2.52 | 0.54 | 45 | 1.71 | 0.24 | <.01 |
| Albumin | 50 | 1.35 | 0.45 | 45 | 0.99 | 0.57 | <.01 |
| Alpha globulin | 49 | 0.44 | 0.20 | 45 | 0.20 | 0.11 | <.01 |
| Beta globulin | 49 | 0.52 | 0.21 | 45 | 0.39 | 0.23 | <.01 |
| Gamma globulin | 50 | 0.19 | 0.03 | 45 | 0.12 | 0.04 | <.01 |
| Total protein (micro Kjeldahl) | 11 | 2.77 | 0.30 | | | | |
| Albumin/globulin ratio | 48 | 1.34 | 0.58 | 45 | 1.60 | 0.77 | >.01 |
| NPN (mg./100 ml.) | | | | | | | |
| Frogs kept less than 2 weeks in cold torpor | 31 | 25.3 | 10.1 | 25 | 29.4 | 9.6 | >.01 |
| Frogs kept more than 2 weeks in cold torpor | 33 | 59.7 | 7.4 | 25 | 63.4 | 13.0 | >.01 |
| Minerals (mEq./L.) | | | | | | | |
| Chloride | 36 | 69.7 | 6.2 | 45 | 63.0 | 6.2 | <.01 |
| Sodium | 30 | 110.9 | 3.7 | 32 | 105.2 | 10.3 | <.01 |
| Potassium | 30 | 1.7 | 0.2 | 30 | 2.7 | 0.4 | <.01 |

[1] Serum from 3 frogs was pooled for each determination (sample).

was available for analysis. To obtain adequate volumes, three ml. of blood serum were generally pooled for each sample, one ml. being obtained per frog. The number of samples used (determinations made) varied with each analysis, as indicated in Table I. All samples were stored at 6° C. and analyzed within 72 hours.

A biuret method (Wolfson *et al., Amer. Jour. Clin. Path. 18: 725–30,* 1948) was used to determine total serum protein and also the major protein fractions. Fractions were determined colorimetrically after being separated under the same conditions of salt concentrations as are the alpha, beta, and gamma globulin and the albumin fractions of man. Total serum protein was also determined as a check, by a modification of the micro-Kjeldahl method (Hawk *et al., Practical Physiol. Chem., 12th ed.,* 1947). NPN was analyzed from protein-free filtrates by the same micro-Kjeldahl technic.

Serum chlorides were determined by the method of Keys (*Jour. Biol. Chem. 119: 389–402,* 1937). Serum sodium and potassium concentrations were determined by the method of Gradwohl (*Clin. Lab. Methods and Diagnosis, Vol. 1,* 1956). The results were subjected to statistical analysis by the Student *t* equation (Student, *Metron 5(3): 105–20,* 1925), interpreting significance at the 1 percent level of probability (P).

*Experimental Results.*—Total proteins (g./100 ml.) by the biuret method decreased significantly in diseased serum. The micro-Kjeldahl method, run in random samples of normal serum as a check upon the biuret method, consistently showed slightly higher total protein values.

Each individual protein fraction decreased significantly in disease. Although globulins tended to decrease more than albumin, the decrease was actually proportionate, since tests of significance showed no real change in the A/G ratio. Albumin was present in highest, and gamma globulin in lowest concentrations in both normal and diseased bloods.

Blood samples used in NPN analysis, both normal and diseased, came from two groups. The first group was kept less than two weeks and the second more than two weeks. The NPN (mg./100 ml.) increased significantly with time in both normal and diseased animals. NPN also tended in the two groups to rise in disease, but this was a non-significant tendency.

Both sodium and chloride (mEq./L.) decreased significantly in disease, while potassium increased significantly.

Numerical values for all experimental results are given in Table I.

*Discussion.*—The significant decrease of total protein in disease could probably be ascribed to impaired protein synthesis, raised protein metabolism and excretion, or the escape of proteins from the blood.

Since most of the nitrogen compounds in se-

rum are formed from the metabolism of proteins, any gross increase in protein catabolism should be reflected in an increase of serum NPN. The NPN did not rise significantly in disease, however, and the increase that did occur could well be attributed to the effects of cold torpor.

Two other factors, singly or together, could account in great degree for the serum protein decrease. Edema and internal hemorrhage are characteristic of the disease. Since the capillaries break down, transudation of serum protein into edema fluids or loss by exsanguination seem likely. Perhaps hematocrit determinations in conjunction with red cell counts would have been useful here.

The hemoglobin released into the blood through hemolysis could conceivably affect the quantitative serum protein values, especially the total proteins. This effect may be negligible since the total proteins decreased in this disease and the A/G ratios were not significantly altered. It is probable that very little destruction of cells occurs in relation to the total number of cells.

The concentration of globulin is less than that of albumin in the normal frog, and it decreased proportionally with albumin in disease. These findings contrast with the increase in serum globulins which usually occurs in mammalian infections. They support the statement that frogs held in the cold are not too capable of producing globulin-fixed antibodies that combat disease (Bucovaz and Kaplan, *Amer. Jour. Physiol. 191: 428–30*, 1957).

The relative concentrations of sodium, potassium and chloride found in normal frog serum are similar to human values (Gradwohl, *op. cit.*). In red leg disease these ions closely follow the common patterns of electrolyte change reported in human diseases (Moore, *op. cit.*), i.e., potassium increases, but sodium and chloride decrease. This is ascribed to a flooding of the extracellular reservoirs, including the blood, with sodium-free water originating in lysis of cells and in the catabolism of sodium-deficient fat and protein reservoirs. Chloride leaves the blood probably in an attempt to maintain electrolyte balance. There is no good explanation elsewhere of the potassium increase, and nothing can be added on the basis of the data presented in this study.

The exact quantities of components found in normal frog serum will vary somewhat with particular conditions. Different investigators report different values because of (a) the failure to control seasonal variations; (b) the use of insufficient samples; (c) species differences; (d) the amount of protein extractable according to the method used; (e) the difficulty of differentiating healthy animals, and (f) the effect of feeding and of environmental temperature. In this study, where the factors were held as uniform as possible for both healthy and diseased frogs, the relative differences found are significant.

*Summary.*—Serum total protein, albumin, alpha globulin, beta globulin, gamma globulin, NPN, chloride, sodium and potassium were quantitatively compared in normal frogs and those with red leg disease, all previously held at 6° C. Diseased animals were naturally infected or else injected with *Pseudomonas hydrophila*.

Serum total protein and each protein fraction significantly decreased in disease. Albumin and total globulin decreased proportionally.

The NPN increased in frogs held in the cold. It was higher in frogs held over two weeks without food in cold torpor than in those held less than two weeks in the same way. This was true for both normal and diseased frogs. The tendency of NPN to rise in disease could be attributed to the effect of cold torpor and not to any metabolic effect of red leg disease.

Sodium and chloride concentrations significantly decreased in disease, while the potassium concentration significantly increased.—L. V. Gibbons and H. M. Kaplan, *Department of Physiology, Southern Illinois University, Carbondale, Illinois.*

THE HELLBENDER, *CRYPTOBRANCHUS ALLEGANIENSIS*, IN ILLINOIS.—The occurrence of the hellbender, *Cryptobranchus alleganiensis* Daudin, in Illinois has been assumed for more than 100 years and the species has been repeatedly credited to the state despite a considerable amount of doubt attached to all of the older records. The acquisition of recent material, which corroborates the presence of this large salamander in Illinois, prompts us to summarize and evaluate all of the previous reports of the species in the state.

The Peoria botanist, Dr. Fred Brendel (*in* Gerhard, *Illinois as it is: 254*, 1857) first listed the hellbender as an inhabitant of Illinois waters. Davis and Rice (*Bull. Chicago Acad. Sci. 1(3): 26*, 1883) noted in their check list of Illinois amphibians and reptiles that *Cryptobranchus* occurred in the tributaries of the Mississippi River, and Garman (*Bull. Illinois State Lab. Nat. Hist. 3: 381*, 1892) stated, on the authority of Robert Ridgway, that it was found in the Wabash River. Despite the several published reports of its occurrence in Illinois, documented records appeared to be lacking. However, in a canvass of the major museums of the country in the late 1940's by one of us (Smith), a specimen bearing the data "southern Illinois" was located in the collections of the Chicago Academy of Sciences. The

specimen, No. 294, was accompanied by no other details; and, as it had obviously been collected many years before, some doubt could be raised as to the accuracy of the extremely vague locality data.

The senior author distinctly recalls, however, that in 1926–27 a specimen, caught in the Cache River near Ullin, Pulaski County, was kept in the zoological laboratories of Southern Illinois University, where it became rather tame and readily took worms when they were offered to it. She also saw two more specimens from the same locality caught in 1937 by Mr. Charles Mayfield. Unfortunately, none of these was preserved, and the records were not published by the collectors. Goodnight (*Trans. Illinois State Acad. Sci. 30(2): 301,* 1937) and Cagle (*A key to the reptiles and amphibians of Illinois: 2,* 1941) included the hellbender in their respective keys to Illinois amphibians. Cagle (*Amer. Midl. Nat. 28(1): 172,* 1942), evidently unaware of the Chicago Academy of Sciences specimen and the three examples from Ullin, noted that there were hearsay reports from fishermen of Devil-dogs (= hellbenders) in the Big Muddy and Mississippi rivers but that no Illinois specimens were extant in museums.

Cognizant of the desirability for preserved material to corroborate the occurrence of the species in Illinois, we independently made inquiries of commercial fishermen along the Wabash, Ohio, and Mississippi rivers in a concerted effort to obtain additional information. Assertions by Mr. S. H. Eaton of Lawrenceville and Game Biologist O. M. Price of Oblong of having seen hellbenders near the mouth of the Embarrass River in Lawrence County suggested that specimens would be forthcoming eventually; and a short time later Dr. Sherman A. Minton told us (*personal communication*) that he had seen in an Indiana fish hatchery a live specimen, said to have been caught in the Wabash River at nearby Vincennes, Indiana. The other Indiana records, according to Minton, are confined to the extreme southeastern corner of the state.

More recently two specimens, now in the collections of Southern Illinois University, were secured in the Ohio River. One was taken at Metropolis, Massac County, on April 15, 1956, and a second was caught at Cave in Rock, Hardin County, in June of the same year. A third specimen, collected in the Wabash River near Maunie, White County, in the spring of 1947 and now in the Biology Laboratory at Carmi Township High School, has been made available to us through the courtesy of Mr. John C. Cralley, the biology teacher in Carmi, Illinois. All recent specimens were taken on baited hooks by commercial fishermen.

Data for the three available specimens, listed in the same order as above, are: snout-vent length 267, 285 and 270 mm., total length 418, 433, and 440 mm., diameter of spiracular opening 6.5, 4.5, and 7.5 mm., ratio between spiracular diameter and internarial distance 2.0, 3.5 and 2.2. The two Ohio River specimens are decidedly bluish slate; the Wabash River specimen, a dirty brown. The Metropolis example is minutely flecked with olive, the other two are uniformly colored or obscurely mottled, although the Cave in Rock salamander has rather heavy pigmentation on the lower jaw. The sum of the characters indicates that the Illinois specimens are referable to the eastern subspecies, *Cryptobranchus a. alleganiensis.* The Cave in Rock specimen approaches the Ozarkian race, *C. a. bishopi,* in the rather small diameter of the spiracle and in the extent of the infralabial pigmentation; but in dorsal pattern, one of the more reliable characters, it is assignable to the nominate subspecies.—HILDA A. STEIN AND PHILIP W. SMITH, *Department of Zoology, Southern Illinois University, Carbondale,* and *Illinois Natural History Survey, Urbana, Illinois.*

# REVIEWS AND COMMENTS

THE FISHES OF OHIO WITH ILLUSTRATED KEYS. By Milton B. Trautman. Ohio State University Press, Columbus, 1957: xviii + 683, 172 maps, 7 col. pls., 172 figs.; $6.50.—Early in the nineteenth century, settlers, pioneers, and homesteaders in constantly increasing numbers crossed the Appalachians and fanned out into the midlands, intent on wresting a living from this new land. Forests were leveled, prairies plowed, milldams constructed, and animal and plant resources ex-

ploited in the struggle of man against the often hostile environment. Few men had time or inclination to step back and examine with detached objectivity the world they found around them; fewer still made a permanent record of what they saw. Such a man was Jared P. Kirtland, pioneer physician and naturalist, who painstakingly assembled careful records of the fishes of Ohio. A century later man has conquered the environment and made it over to his liking. There is no longer a dearth of naturalists, but there are few who have brought to bear on a specific problem the zeal and prolonged devotion that Milton Trautman has lavished on Ohio fishes. There are other state and regional ichthyologies, and there will be more. What makes *The Fishes of Ohio* different and at the same time constitutes its primary message is the picture of faunal change resulting from the onslaught of civilization. Few states had a Kirtland, no other has a modern ichthyologist who for a third of a century has concentrated such intensive study on its fishes. It took a Trautman, teamed with Kirtland, Osburn and other predecessors to elucidate the graphic change that has beset the fish fauna of Ohio in the past century.

In order to treat 172 forms in a single volume the author and publishers of necessity placed rigid limits on the material to be included. General sections, keys and associated material are allocated 130 pages, species accounts 488 pages, and literature cited and index 65 pages. This permits only three pages for the account of most species (160) and additional subspecies (12), each including a large Ohio distribution map, a small insert map showing general distribution, and illustrations. The latter comprise not only a detailed lateral view, but for many species additional drawings to depict sex dimorphism, notable differences between young and adults, dorsal view, and diagnostic characters. For each species, text material is restricted to brief (but adequate) comments under identification, and a section treating Ohio distribution and habitat. Most of the original contribution of the work appears in the paragraphs on Ohio distribution together with the state maps. For those who are aware of Trautman's vast storehouse of original information on the natural history of Ohio fishes, the lack of even summary paragraphs on reproductive behavior, food relations, growth, movements, and other aspects of life history constitutes the greatest disappointment in the volume. Some such information appears under distribution and habitat, but one wonders why the student, fisherman or other lay reader, and the professional fishery worker is not furnished a section on habits and life history. This is especially regrettable since efficient use of space would have permitted the addition, by my computation, of over 80 full pages of text material in the systematic section without increasing the size of the volume by a single page. Only 20 percent of the species accounts terminate near the bottom of a page; many pages have only a few lines of type.

Introductory chapters treat of the topography, climate, and glacial history of Ohio (of general interest); of two centuries of human occupancy of the state and the resultant changes (a fascinating and surprisingly well documented historical account, but canal development and its possible role in modifying fish distribution is omitted); of the concordance of identifications of earlier workers with those adopted by Trautman (of interest chiefly to bibliophiles); of the nature of scientific and common names (Trautman has been instrumental in the adoption of fewer, more expanded genera; he apparently subscribes to the 75 percent rule for subspecies); methods of taking counts and measurements on fish specimens, together with a thorough glossary of technical terminology (excellent); keys for identification (very thorough, reliable, and workable); comments on hybridization together with a list of hybrid combinations recorded from Ohio (adequate); and sources of information, gazeteer of localities, and methods employed in the systematic account—especially maps and illustrations. The handsome colored paintings of 21 species by Mrs. Lydia Hart Green constitute a welcome addition to the illustration of American fishes. Unfortunately, there is no size scale. Mrs. Green also prepared some of the colored paintings for Forbes and Richardson's *Fishes of Illinois*.

All book-minded Ohio anglers, every student of freshwater fishes, and many other naturalists will want to own this volume. Before it is placed on the bookshelf, however, I urge them and others concerned with the place of water use and fishery resources in modern society to read Part II, which reconstructs vividly the transition from an unspoiled forest-prairie wilderness to a heavily populated, agricultural-industrial region.

In addition to the minor deficiencies and errors that seem to find their way into any such broad undertaking, there are certain features that I believe should be avoided or corrected by others attempting a comparable assignment. The drawings are painstakingly executed and have good line work. They admirably serve their primary function in bringing out diagnostic details, but the technique adopted does not result in good perspective. Some errors creep in; for example, one would conclude from figure 51 that *Hypentelium nigricans* has eight scale rows around the caudal peduncle whereas it actually has 16. Fin

rays are often much too slender, and frequently the last (double) ray in the dorsal and anal fins is inaccurately shown. On page 129, Trautman explains how drawings were made. "All measurements of curved surfaces, such as the snout measurement, are actual measurements and are not foreshortened as they frequently are in photographs, paintings and artistic drawings." Thus, his figures are highly schematic. For a much compressed fish and for measurements which closely parallel or lie in the sagittal plane the result is satisfactory, but to plot a broadly diagonal measurement, such as the snout length of a catfish, on the same lateral diagram introduces distortion. In this reviewer's opinion, the lateral drawings of catfishes would have been improved by showing barbels on only one side of the head.

The systematic list includes no separate accounts of families and genera; therefore, and to avoid repetition, "general" characters appear only under the first listed species of a family, "generic" characters only under the first species of a genus, "specific" characters only for the first subspecies of a species. Much page-thumbing is necessary to get a full characterization. Similarly, the elaborate index is not always easy to use.

The data on which the distributional spot maps are prepared are exhaustive (page 119). The base map was carefully drafted, and the individual maps are large, clear, and most are models of excellence. A scale of miles would have added a cartographic nicety. Pertinent physiographic boundaries that give meaning to the distributional patterns are included on many maps. For some species, collections taken during different time intervals are plotted with different symbols. Where only two sizes of spots appear the maps are clear, but with three or more they are cluttered and unsatisfactory (*e.g.*, maps 78 and 106). The introduction of occasional dubious records (*e.g.*, maps 55 and 56) vitiates the primary visual function of the map. Various lines and symbols on the maps are identified in the captions by printer's symbols that bear only faint resemblance. Adequate general distribution maps have been published for so few fishes that it was an ambitious undertaking to prepare these for all species. As warned by Trautman, the accuracy of these small insert maps varies inversely with distance from Ohio, so they should be used only as rough representations of general distribution. When more areas are studied as Ohio has been, more reliable maps will be possible.

Outright errors of fact are few. However, in view of Vladykov's recent discoveries on identification of lamprey ammocoetes, which have been abundantly verified in our laboratory, I am forced to contradict Trautman's assertion (p. 74) that ammocoetes cannot be identified using morphological characters. The economically important sea lamprey and at least several other species can be positively identified at even smaller size than was done by Vladykov. The specific name of *Opsopoeodus emiliae* is misspelled in both text and index (though not in the key). This species is credited with having a pharyngeal tooth count of 1,4–4,1 or 4–4; actually it has 5–5. Trautman is almost if not entirely alone among ichthyologists in capitalizing common names of fishes. His compounding of names like goldenshiner and blackbass seems to have little merit and a negligible following. Although it is shown that geographic distribution changes with time, the use of past tense in the discussions of habitat seems unnecessary. The text is highly readable and has few typographical errors.

Among the twelve species treated as including two Ohio subspecies, three (*Carpiodes cyprinus*, *Stizostedion vitreum*, and *Cottus bairdi*), and possibly a fourth (*Coregonus artedii*), have two sympatric subspecies living in Lake Erie. In each case one form is characteristic of the deeper, cooler, clearer waters of the eastern part of the lake, the other of the western part and shore areas. The subspecies are justified only by rather general statements, and the text includes some evidence to throw doubt on the validity of each separation. Further study is necessary before the relationship of these forms is well understood.

*The Fishes of Ohio* ranks as the finest regional ichthyology yet produced. It's selling price is below cost and a bargain umatched in this day of rising book costs. A wide circle of workers will find it a reference to be kept within arm's reach. With the passage of time its obsolescence through increments to knowledge will be more than compensated for by gain in historical value. Thus, one may predict a long and useful life for this monograph. I am proud to have had even a slight association with the production of this splendid monument to Dr. Trautman's industry and enthusiasm.—REEVE M. BAILEY, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

ANATOMIE DE *LATIMERIA CHALUMNAE*. TOME I. SQUELETTE, MUSCLES ET FORMATIONS DE SOUTIEN. By J. Millot and J. Anthony. Centre National de la Recherche Scientifique. Paris. 1958: 122 pp., 30 text-figs., frontispiece + 80 pls. 10,000 fr. (about $20).—Ever since the discovery of the first *Latimeria*, those interested in vertebrate evolution and vertebrate structure have been eagerly looking forward to a knowledge of the anatomy of this surviving crossopterygian. To be sure, the coelacanth branch of the crossopterygians had obviously de-

parted in mode of life far from the conditions presumably present in ancestral crossopterygians, and (as already suggested by knowledge of fossil skeletons) have presumably departed likewise in many ways from the structural plan of the ancestors of the group. Nevertheless, *Latimeria*, without question, gives the closest approach to this pattern that we can ever hope to find.

Appetites have been whetted by a number of short preliminary papers published by Millot and Anthony during the last few years and by a well-illustrated publication on the fish's surface characters. We now have before us a magnificently illustrated volume describing the skeleton and musculature. A second volume, concerned with the nervous system, is promised within the year.

Ten specimens—seven males and three females—were available for the work. Dissection was relied on, in the main, but radiography was used to determine the extent of ossification, particularly in the head region, and frozen sections were made—notably a complete series of transverse head sections at 3.5 mm. intervals, and longitudinal sections of a second head.

The volume is of quarto dimensions but of unusual format. Text and plates are bound separately and so arranged that when the book is opened the two parts lie side by side, making it possible to see both text and figures without the vexatious constant turning to and fro required with normal binding. In the 122 pages of text are included 30 line drawings, a number of them colored to show muscle attachments, lateral-line elements and so forth. The majority of the 80 plates are excellent photographs of dissections and sections; there are, further, a number of X-ray photographs and finely executed drawings, in color, of fin structure. In about half the series the page opposite the photograph bears a detailed and fully labeled drawing of the structure or section photographed.

A considerable portion of the account is, quite naturally, devoted to cranial structures and, most especially, to the braincase. As first pointed out by Watson, the crossopterygian braincase is unique and radically different from that of any other vertebrate group in being divided into quite distinct anterior and posterior moieties, movably articulated with each other. We have accumulated considerable knowledge of the rhipidistian braincase, but have known little of that of coelacanths. The braincase was ossified in the earliest forms, but the material is imperfect; in later genera ossification was sharply reduced and hence but little could be learned from the fossils. The complete, detailed account given here shows us a braincase comparable in most major features with that of rhipidistians, but differing notably in certain regards. Most prominent of differences is the presence in the snout of the large pocket and tubular orifices of the rostral organ—an organ, to be described in a later volume, which is peculiar to coelacanths and of which the presence was quite unsuspected before the discovery of *Latimeria*. Notably different also from rhipidistian structure is the extremely large endocranial cavity, within which is a brain of relatively diminutive proportions—a condition embarrassing to those of us who feel that in general the brains of fossil forms can be restored with confidence on the basis of the evidence of cavity contours and nerve exits.

The anterior, ethmosphenoid, segment is completely cartilaginous except for small paired ossifications, termed by our authors ectethmoids, in the nasal region and, posteriorly, a stout median ventral basisphenoid in the region of the pituitary, and the articulations with the posterior element. I had several decades ago found in the Texas Permian redbeds several isolated examples of a bone of complex and distinctive structure which I was unable to identify until, in studying the rhipidistian braincase, it became clear to me that it must be the basisphenoid of a coelacanth. It is, to me, thrilling to see in specimens of this living fish, a bone almost identical with that of its Permian ancestor. There is no myodome (thought to be present by earlier workers on coelacanths) nor is there any ossification corresponding to the sphenethmoid, prominent in early tetrapods and hence assumed to have been present in their rhipidistian ancestors.

The posterior segment of the braincase is basically comparable to that of rhipidistians. Here, too, there has been reduction in ossification; but the reduction is not as extreme as in the anterior moiety. A number of dermal elements are closely applied to its dorsal surface and the upper part of its side walls; endochondral elements include a well-developed supraoccipital, small exoccipitals, basioccipital elements both above and below the chordal canal, massive prootics and small ventral "preoccipitals." There is, as in rhipidistians, a prominent lateral projection on either side to which attach the two articular processes of the hyomandibular and through which passes a large "jugular" canal. As I had assumed in the case of "*Megalichthys*" this canal affords passage to the facial nerve and the lateral head vein; the authors note, however, that my further assumption of the presence here of an orbital artery was incorrect—for this coelacanth, at any rate. Ventrally the otico-occipital mass is traversed by the enormous antero-posterior canal found in other crossopterygians but (until the recent description of ichthyostegids by Jarvik)

absolutely unknown in any other vertebrate group. Stensiö at one time thought this was occupied by musculature. My studies of the "*Megalichthys*" skull convinced me that, on the contrary, it was filled by an extension of the notochord which attached anteriorly to the back surface of the basisphenoid, thus giving a firm but flexible connection between the two cranial segments. When I first put forward this suggestion I had no idea that it would ever be possible to confirm it. It is very pleasant to see the hypothesis become concrete fact.

Because of the reduction of the dermal elements of the skull roof, interpretation of the lateral-line system and pit lines in fossil coelacanths had been difficult. Smith's original specimen had yielded considerable information on these structures, and Millot and Anthony have added further data.

The general topography of the coelacanth palatoquadrate complex has for some time been known from fossil forms; the account of *Latimeria* supplements previous knowledge with data on such features as, for example, the presence of continuity in cartilage between quadrate and epipterygoid (metapterygoid). As pointed out by Millot and Anthony, *Latimeria* has departed from primitive jaw structure in the loss of both basal and otic articulations with the braincase, although preserving an antotic connection. The hyoid arch is highly developed; the hyomandibular is short and broad, but corresponds in structure to that of rhipidistians and, as deduced in "*Megalichthys*," has a canal traversed by the main trunk of the facial nerve. The branchial arches, as Stensiö had noted in fossil coelacanths, are reduced from the rhipidistian condition—particularly the fifth arch. There is a prominent urohyal in the floor of the mouth which includes both a dermal component (as in actinopterygians) and an endochondral one (as in urodeles).

A surprising find in the shoulder girdle of *Latimeria* is that reduction of the dermal elements is such that, in contrast to the vast majority of bony fishes, articulation with the skull table is lost. The endoskeletal girdle is of simple structure, including a single ossification and slender dorsal and ventral cartilaginous extensions, with little that is readily comparable with tetrapod structures. Here, as in fossil coelacanths generally, the area articulating with the fin is cartilaginous. In contrast with tetrapods—and hence with presumed tetrapod ancestors—the articular surface for the limb in both pectoral and pelvic girdles is convex, the proximal limb segment bearing a socket. This feature, the authors suggest, is associated with the extreme mobility of the fin, which in life could be rotated a full 180°. The pectoral and pelvic fin skeletons (seldom preserved in fossil coelacanths, because of their usually cartilaginous condition) show little branching, except distally, from their main axis of four or five segments, and hence depart from the pattern expected in primitive tetrapods.

Knowledge already in hand from fossil forms had made it apparent that the postcranial axial skeleton of the coelacanths was poorly developed as regards ossification, at least. *Latimeria* shows that skeletal reduction was even greater than had been realized, for in the vertebral region even cartilage is much reduced. The enormous notochord extends backward along the trunk without the slightest constriction or invasion by cartilaginous elements. Above, there are applied to the dorso-lateral surfaces of the notochord a series of more than a hundred paired cartilage elements which the authors (following the Gadow nomenclature) term basidorsals, but consider as possibly representing both basidorsals and (hypothetical) interdorsals. Prominent anteriorly, these neural arches decrease in size posteriorly; in compensation, however, there appear elongate neural spines in which, alone of axial elements, ossification may appear. Ventrally there are throughout the column inconspicuous elements which Millot and Anthony term basiventrals; to them in the caudal region are attached slender haemals, which form chevrons for part of their extent. In some fossil coelacanths ossified rib elements are known; in *Latimeria* there is not a single rib, dorsal or ventral, ossified or cartilaginous.

The general pattern of coelacanth median fins has long been known, but because of feeble ossification, particularly in the less ancient fossils, details have been incompletely known. Millot and Anthony give a detailed description, with figures, of a first dorsal in which little skeleton is present beyond a basal plate, of pedunculate second dorsal and anal, with a skeleton remarkably similar to that of the paired fins, and a typically trifid crossopterygian caudal, in which (as in the specimen named *Malania* by Smith) the small terminal lobe is sometimes atrophied.

Paralleling their description of each portion of the skeleton is given an account of the associated musculature. Most notable in the cranial region is the development of special muscles connecting, ventrally, the anterior and posterior moieties of the braincase. Given the known possibilities of movement of these segments on one another, the presence of muscles to aid or oppose intracranial movement might be deduced; but the massiveness of the ventral "subcranial" muscles is astounding while, on the other hand, there is no trace of opposing dorsal muscles. The innervation of the subcranial musculature is not

given; logically, since its function is of an axial nature, one would expect it to be somatic motor, but presumably these muscles are members of the trigeminal visceral series, related to the pterygoid muscles.

The musculature of the paired fins is well described and there are excellent diagrammatic figures showing areas of origin and insertion. These muscles seem to be grouped for the most part into two opposed series, abductors or elevators and adductors or depressors (dorsal and ventral muscle groups of the reviewer's classification) with specialized smaller slips, supinators and pronators, for rotary movements. The innervations will presumably be given in a later publication on the nervous system. Once this is available, *Latimeria* will furnish valuable evidence on the origin of tetrapod limb musculature (in my earlier studies, in default of crossopterygian evidence, I was forced to rely on lungfish and actinopterygians in an effort to deduce ancestral fish conditions). Further, although the pelvic girdle is obviously far from primitive, interpretation of the musculature should be of value in studying the origins of the tetrapod girdle.

It is perhaps ungrateful to ask anything of Drs. Millot and Anthony in addition to the magnificent series of illustrations of the skeleton and muscles they have given us. But I do find one difficulty. All the separate elements of the cranial anatomy are described in very satisfactory fashion. But it is in many regards difficult to visualize the region as a unit; to quote the old adage, it is difficult to see the forest for the trees. Perhaps in some concluding volume of their work, the authors will favor us with a series of diagrammatic "dissections" of the cranial structures as a whole, in which not only skeletal elements but muscles and nerves and blood vessels could be shown in their relations to one another.

This volume is a splendid contribution to the advancement of our knowledge of vertebrate anatomy and evolution. We look forward with pleasant anticipation to accounts of the nervous system, blood vessels and viscera.—A. S. Romer, *Museum of Comparative Zoology, Harvard University.*

A number of classic works have been republished. The attention of *Copeia* readers is called to:

THE GENETICAL THEORY OF NATURAL SELECTION.
By Ronald A. Fisher. 2nd Revised Edition.
Dover Publications, Inc., New York. 291 pp. $1.85 (Paperback)

STUDIES ON THE STRUCTURE AND DEVELOPMENT OF VERTEBRATES.
By Edwin S. Goodrich.
Dover Publications, Inc., New York. 2 vols., 837 pp. $5.00 for the two volumes. (Paperback)

A STATISTICAL STUDY OF THE RATTLESNAKES.
By L. M. Klauber.
San Diego Society of Natural History Occasional Papers nos. 1, 3–6. No. 1 priced at .15 and nos. 3–6 at .30 each.
Available from the *Librarian, Natural History Museum, Balboa Park, San Diego, California.*

# Editorial Notes and News

**Paul Chabanaud**

The family of Dr. Paul Chabanaud informs us of the death of this distinguished ichthyologist, Honorary Foreign Member of the American Society of Ichthyologists and Herpetologists, and Chevalier of the Legion of Honor. Monsieur Chabanaud passed away in Paris on February 27, at the age of 82. Although some research early in his career involved African herpetology, he is best known as an extremely able and productive systematic ichthyologist. Much of his recent work was on the anatomy, phylogeny, paleontology, and conventional systematics of the flatfishes.

**Myron Gordon**

The Society suffered a great loss with the death of Dr. Myron Gordon on March 12. Dr. Gordon, for many years in charge of the Genetics Laboratory of the New York Zoological Society at the American Museum, was a great scientist and prolific author in the field of fish genetics. His lifetime work on the genetics of *Xiphophorus* and his recent re-

searches on the inheritance of cancer are well known to most members of ASIH.

**Richard D. Miller**

WORD has been received of the untimely death of PROFESSOR RICHARD D. MILLER, Department of Zoology, University of Alberta, Edmonton, Canada. DR. MILLER was especially known for his extensive work on fish parasites, on the fisheries biology of Canadian lakes, and for his contributions to limnology. Although the research he had completed is outstanding; the loss to ichthyology is that death occurred at an age when greatest productivity was forthcoming.

**J. R. Pfaff**

A RECENT communication from DR. ANTON F. BRUUN in Copenhagen notes that DR. J. R. PFAFF, Curator of Vertebrates in the University Zoological Museum, passed away in April. DR PFAFF published on fishes from Sudan and on the ichthyology and herpetology of Denmark and was highly esteemed by his colleagues for the meticulous care he gave to collections in his charge and for his cooperation with other investigators. DR. F. W. BRAESTRUP, herpetologist and mammalogist at the same institution, succeeds CURATOR PFAFF.

**Norman B. Scofield**

NOTICE has been received through DR. CARL L. HUBBS of the death on November 27, 1958, of MR. NORMAN B. SCOFIELD in Palo Alto. In his early years he published on fishes of the Colorado River and on the Arctic. For many years he was in charge of fish and fisheries work for the California Department of Fish and Game, and was primarily responsible for the initial development of the California State Fisheries Laboratory. He retired from State service in 1940.

**Fritz Mayer**

DR. CARL L. HUBBS also calls our attention to the death on November 18, 1958, of the world-famous, German aquarist, FRITZ MAYER. He died in his home in Hamburg at the age of 82. He was the author of a large number of articles on aquarium fishes, and illustrated his work prolifically. MR. MAYER kept in touch with ichthyologists, and contributed in this way, as well as through his own observations and writings, to ichthyology.

**News Notes**

DR. SHERMAN A. MINTON, JR. writes that his present position is that of visiting professor of microbiology at the Basic Medical Science Institute, Karachi. The chief purpose of this institute is to train Pakistani physicians who will teach the preclinical sciences in Pakistan's medical schools. Various complications have greatly delayed the opening of this institute, but it is hoped that teaching will begin about the first of April. Because of the delay he has had a good deal of time for herpetological field work. He reports that the Karachi area has not proved to be easy because there are few good roads, the rural people speak little or no English, and the summer heat and dust make collecting difficult. Collectors who have worked the Mexican border country would feel right at home in the Sind Desert.

According to DR. MINTON, the herpetofauna of the Karachi area shows a closer affinity to that of the Middle East than to that of peninsular India with xerophilic genera such as *Uromastix, Acanthodactylus, Spalerosophis,* and *Echis* predominant. Typically Indian species such as *Lissemys* and *Rana tigrina* are largely confined to the Indus floodplain. Marine snakes and turtles are found in the coastal waters. There is a rich *Chelonia* nesting grounds within a short drive from Karachi, and turtle eggs occasionally appear on the Minton's breakfast table. DR. MINTON and his wife have introduced the American technique of cruising roads at night for snakes and report that they find it superior to the use of the flute and bowl of warm milk advocated by local snake wallahs; although, with gasoline at more than 50 cents a gallon, it is admittedly expensive. One snake per 25 miles driving has been about the average. *Echis carinatus* and *Eryx johni* are the species most often taken. A DOR sea snake picked up a few yards from a bridge over a tidal creek has been the most bizarre find to date. They challenge friends in the States to top this tale.

JACK S. DENDY of Alabama Polytechnic Institute, Auburn, Alabama, will be on leave for one year to serve as a Fisheries Officer, Limnologist, working with the Philippine Bureau of Fisheries. This is an appointment by F.A.O. for the Technical Assistance program. He will be stationed in Manilla and is to work on the lakes of the Islands. He and his family will arrive in Manila on or about the first of April.

BRUCE W. HALSTEAD, formerly of the School of Tropical and Preventive Medicine, College of Medical Evangelists, Loma Linda, California, has recently been appointed Director of the World Life Research Institute presently under construction on a 60-acre tract in Reche Canyon, Colton, California.

The new institute will be operated as a nonprofit scientific-educational organization with emphasis being placed on fundamental research in the broad field of natural products chemistry, i.e., phytochemistry and marine biotoxicology. The

application of these compounds to medicine and industry are also of direct interest to the organization. Research will be conducted under contract and grants-in-aid from government and industry. A technical assistance program will be developed working in conjunction with certain underdeveloped countries in natural products chemistry. Associated with the new institute will be a community science educational program through the development of a Science Park which will ultimately house a Museum of Medical Natural History, Conservatory of Economic Plants, Aquarium of Medical-Marine Biology, and a Youth Science Program.

ROBERT R. MILLER and graduate student R. JACK SCHULTZ returned on April 6, from nearly three months of field work in Mexico, where studies of *Poeciliopsis* and other freshwater fishes were continued. Live shipments of fifteen forms of *Poeciliopsis* and of one species of *Mollienesia* were successfully flown to Ann Arbor for further genetic analyses. The work is supported by the National Science Foundation.

WILLIAM E. DUELLMAN has been appointed Assistant Professor of Zoology and Curator of Herpetology at the Museum of Natural History, University of Kansas, Lawrence, Kansas. He will begin his duties August 1, 1959.

ROGER CONANT is again actively engaged in his studies on North American *Natrix*. During his long preoccupation with "A Field Guide to Reptiles and Amphibians" he continued his interest and correspondence on the subject, but was unable to make any substantial progress. He is now able to resume activities and to devote considerably more attention to water snakes. He would be very much interested in learning about recently acquired critical material, unusual specimens, extensions of known ranges and other pertinent information, and he requests the cooperation of ASIH members who can contribute to our knowledge of American *Natrix*. The CONANTS are spending most of the summer in Mexico, making field studies on the water snakes indigenous to that country.

**Academy of Natural Sciences**

ENDOWMENT of fish research in the Academy of Natural Sciences of Philadelphia was announced February 26, 1959, by DR. H. RADCLYFFE ROBERTS, Director. Donors of the endowment are MR. and MRS. CHARLES C. G. CHAPLIN, of Haverford, Pa. MR. CHAPLIN is a Trustee of the Academy and a Research Associate in the Department of Fishes, Amphibians and Reptiles. MRS. CHAPLIN is a member of the Women's Committee of the Academy. This gift results from MR. CHAPLIN'S interest in the Academy as well as that of MRS. CHAPLIN, the former LOUISE CATHERWOOD. DR. ROBERTS points out that their generosity makes possible perpetual support of one of the most important phases of the institution's revitalized research program. The CHARLES and LOUISE CHAPLIN Fund, the official name of the contribution, endows the Chaplin Chair of Ichthyology. DR. JAMES E. BÖHLKE, Associate Curator, will be the first incumbent. Since 1954, MR. and MRS. CHAPLIN have supported a program for the study of Bahama reef fishes in the Academy. With collecting in the Bahamian waters, and research in a laboratory at Nassau, where the CHAPLINS have a winter home, and in the Academy, extensive preparatory work has been done by MR. CHAPLIN and DR. BÖHLKE toward a manual of the fishes of the areas around the Bahamas.

**University of Maryland**

DR. RICHARD HIGHTON, Assistant Professor of Zoology is studying the life history and systematics of the salamanders of the genus *Plethodon*. He is especially interested in geographically variable pigmentation and segmentation characters and is attempting to determine their mode of inheritance. DUVALL JONES, who is working with DR. HIGHTON, is interested in geographic variation in the frog, *Pseudacris triseriata*, in the Chesapeake Bay region.

DR. HOWARD E. WINN has completed over two years of work on the comparative reproductive behavior of darters with support from the National Science Foundation. Problems in progress by DR. WINN with graduate students are senses and feeding in darters, sound conditioning in darters and minnows, sexual discrimination in the johnny darter, ecology and behavior of the toadfish, and sound production in catfish. MR. DONALD OBERACKER recently completed an M. S. thesis on a study of two populations of *Merluccius bilinearis* (Mitchell) by use of the De Lury regression method of estimating a population. He is now employed by the Fish and Wildlife Service at Woods Hole. MR. ANTHONY PICCIOLO has completed a problem on the ontogeny of the anal suspensorium in two gerrids and has initiated a Ph. D. thesis on the sexual discrimination and reproductive behavior of several species of gouramies. Other theses in progress are as follows: MR. JOHN STOUT, reproductive behavior and annual gonadal cycles in *N. analostanus* and *N. spilopterus*; MRS. GRACE-ANN GRAY, behavior and sound production of the toadfish; and MR. THOMAS SAVAGE, evolution and behavior of several species of *Cottus*. A recent grant by the Office of Naval Research on studies of the behavior of fishes with special reference to sensory capacities (emphasis on sound and behavior) has commenced. Minnows, catfishes, darters, toadfishes, and certain tropical aquarium fishes are being

utilized. Future work will be extended to coral reef fishes.

DR. A. JAMES HALEY has under study the host-parasite relations of the fish copepod parasite, *Lernea cyprinacea*. DR. HALEY, with students, is carrying out projects on the helminth parasites of the fishes of Chesapeake Bay. The subject of a thesis by MR. JOHN PARKER is the biology of a monogenetic trematode infection of goldfish. Several other species of parasites of freshwater fishes are under study.

DR. GORDON RAMM is studying the reproductive cycle in the striped bass with regard to gonadal, pituitary, and thyroid changes.

**United States National Museum**

Since news from the National Museum was last reported a new staff member joined the ichthyological group. DR. DANIEL M. COHEN, formerly of the University of Florida, was appointed ichthyologist with the Ichthyological Laboratory of the United States Fish and Wildlife Service. He is continuing his studies on bathylagid fishes of the world and has just completed an account of the western North Atlantic argentinoid fishes which will be included in the forthcoming volume of "Fishes of the Western North Atlantic." He has also commenced a study of western North Atlantic Anacanthini (exclusive of Macruridae) to be included in the same monograph.

DR. LEONARD P. SCHULTZ (and collaborators) saw proof on volume two of United States National Museum Bulletin 202, The Fishes of the Marshall and Marianas Islands. He is completing a review of the Sternoptychidae which is being prepared for publication in the Museum's Proceedings and a portion in the "Fishes of the Western North Atlantic." In addition to his continuing interest in South American freshwater fishes, DR. SCHULTZ is also contributing to the progress of the current AIBS—Navy shark attack study.

DR. ERNEST A. LACHNER, Associate Curator of Fishes, has in completion stages the gobioid sections for the "Fishes of the Marshall and Marianas Islands," U. S. National Museum Bulletin 202, volume 3. Work on the systematics and natural history of the Echeneidae, reported at the last ASIH meeting and more recently to the staff of the U. S. National Museum, is nearing completion. Revisions of the Apogonidae and Mullidae are in progress.

DR. WILLIAM RALPH TAYLOR, Associate Curator of Fishes, continues his study of the fishes of Arnhem Land, Australia, based principally on collections obtained by the National Geographic Society—Smithsonian Expedition of 1948.

ROBERT H. KANAZAWA, author of a recent issue of the Proceedings, included some of his findings on the Congridae and he is continuing his studies on related eel groups.

DR. GILES W. MEAD, Director, Ichthyological Laboratory, U. S. Fish and Wildlife Service has completed a revision of the North Atlantic benthonic iniomous fishes for part three of the "Fishes of the Western North Atlantic." He is also working on a problem of reproductive specialization in these fishes. DR. MEAD's work on the Bramidae is proceeding intermittently as specimens become available for study, and he is especially interested in obtaining adults of any of the species from any locality, for these are indispensible for the identification of the abundant juvenile series represented in the *Dana* collection now under study. DR. MEAD is participating in the organization of a symposium on the North Atlantic redfish, *Sebastes marinus*, which will be held in Copenhagen next fall. He is also working with DR. BIGELOW on the editorial tasks associated with "Fishes of the Western North Atlantic."

DR. WILLIAM A. GOSLINE, Professor of Zoology, University of Hawaii currently on sabbatical and a Guggenheim Fellowship during his leave, has returned from the British Museum and will remain at the U. S. National Museum until June, 1959. While in London, DR. GOSLINE studied the evolution of the caudal skeleton in the Malacopterygii. He will continue his study here, based on the material currently available in Washington.

DR. DORIS M. COCHRAN, Curator of Amphibians and Reptiles, continues her studies of South American frogs. In addition, she has in the editor's hands a catalogue of herpetological type specimens housed in the U. S. National Museum.

Also of especial interest to Society members is the building program of the Smithsonian Institution now under way. Two new wings to the Natural History Building are on the priority list and are in an advanced stage of planning. The first floor of the west wing will contain the fish staff and collection, and herpetology will be located on the second floor. Two new halls in the Natural History Building are in progress and are of interest to Society members too, one on Marine Life and one covering Vertebrate Paleontology.

Society members are urged to announce and plan their visits to the museum several months in advance for the expanded staff has put working space and equipment at a premium. It is extremely difficult to fulfill adequately the needs of visitors who arrive and announce their presence on a Holiday weekend. The loan of collections also should be planned in advance. Apparently few Society members are aware of the Institution regulation prohibiting the shipping of specimens and similar material during most of the month of December when the mails are "heavily loaded."

**Michigan Fisheries** A new serial publication *Michigan Fisheries* is announced. The new periodical is published occasionally and numbered serially. To date Numbers 1 and 2 have appeared. The first is a list of fishes of the Great Lakes and tributary waters by CARL L. HUBBS and KARL F. LAGLER; the second is entitled "The exchange of technical information in fisheries" and lists reprints which are available to individuals on request but which will not be generally distributed except to libraries and agencies.

**Grassland Research Foundation** THE GRF is an independent organization devoted to research and conservation in grassland areas. It is concerned with the populations, life histories, requirements, limiting factors and other ecological relations of the plants and animals that make up a grassland community, and the responses of the community as a whole. The GRF's chief field of operation is the Great Plains (especially west of 100° W) and the eastern and southern foothills of the Rocky Mountains in the United States. One of our main objectives is to encourage and promote grassland research in the colleges and universities of this geographical area.

A GRF committee under the chairmanship of ADOLPH M. STEBLER (U. S. Fish and Wildlife Service, Stillwater, Oklahoma) is investigating a large area in the Santa Fe Trail—Cimarron River region with the view of implementing its preservation, combining (*a*) an area for basic research on grassland organisms, (*b*) a national monument, and (*c*) land devoted to wildlife management. Other GRF committees have been assigned the preparation of a series of short papers to stimulate interest in grassland research. The first of these entitled "Aspects of Needed Research in North American Grasslands" is to be published in the *Transactions of the Kansas Academy of Sciences*.

ASIH members interested in grassland research, and especially those resident in the Great Plains region, are invited to join the GRF. Applications for GRF membership should be sent to the Secretary, DR. HAROLD M. HEFLEY, *Panhandle A. and M. College, Goodwell, Oklahoma*. Annual dues are $2.00 for regular members and $10.00 for sustaining members.—V. E. SHELFORD, Chairman, Scientific Advisory Board; H. S. FITCH, President.

**Vertebrate Morphology Symposium** ZOOLOGISTS are invited to attend the Second Symposium on Vertebrate Morphology being scheduled with the American Society of Zoologists for the AIBS meetings at Penn State University, August 31, to September 2, 1959. The meeting is being held to discuss the aims, purposes, and needs for some type of organization for Vertebrate Morphology.

A symposium was held as a scheduled part of the December, 1958, meeting of the A.S.Z. in Washington, D. C. The symposium was organized by DR. ALFRED S. ROMER primarily to bring together those doing research in this subject to form a Section of Vertebrate Morphology within the A.S.Z. The meeting was highly successful and was attended by approximately 150 persons. Titles of the papers presented at the 1958 symposium are listed in volume 132 of the *Anatomical Record* (pp. 384, 387, 390, 392). A quick glance at the titles will indicate the diversity of subject matter covered at the sessions.

Since considerable enthusiasm was expressed in favor of a Section of Vertebrate Morphology, an Organizing Committee was set up to investigate the matter further, and to take the necessary steps to establish the Section. The committee consists of DR. BOBB SCHAEFFER, *The American Museum of Natural History* (Chairman); DR. HARVEY I. FISHER, *Southern Illinois University*; DR. PERRY W. GILBERT, *Cornell University*; DR. ALFRED A. ROMER, *Harvard University*; DR. RICHARD J. BALDAUF, *Texas A. and M. College*.

The response at Washington indicates that a separate organization for Vertebrate Morphology is both highly desirable and feasible. If you are engaged in research on any phase of vertebrate anatomy or embryology (comparative, descriptive, functional), on problems of vertebrate evolution, or the use of morphologic criteria in systematics, or on any other subjects which could properly be fitted into the scope of the proposed organization your comments and active participation in the meetings at Penn State are earnestly solicited.

**National Science Foundation** THE Division of Biological and Medical Sciences of the National Science Foundation announces that the next closing date for receipt of basic research proposals in the Life Sciences is September 15, 1959. Proposals received prior to that date will be reviewed at the fall meetings of the Foundation's advisory panels and disposition will be made approximately four months following the closing date. Proposals received after the September 15, 1959, closing date will be reviewed following the spring closing date of January 15, 1960. Inquiries should be addressed to the *National Science Foundation, Washington 25, D. C.*

# COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

## Officers

*Honorary President*—HELEN T. GAIGE, 1211 Ferdon Road, Ann Arbor, Michigan.

*President*—REEVE M. BAILEY, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

*President-Elect*—NORMAN E. HARTWEG, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

*Vice-Presidents*—(Conservation) M. GRAHAM NETTING, Carnegie Museum, Pittsburgh 13, Pennsylvania; (Finance) JOHN C. BRIGGS, Dept. of Anatomy, University of British Columbia, Vancouver 8, British Columbia; and (Membership) JAMES KEZER, Dept. of Biology, University of Oregon, Eugene, Oregon.

*Treasurer*—JAMES E. BÖHLKE, Academy of Natural Sciences, 19th and Parkway, Philadelphia 3, Pennsylvania.

*Secretary*—ROGER CONANT, Philadelphia Zoological Garden, 34th Street and Girard Avenue, Philadelphia 4, Pennsylvania.

*Publications Secretary*—N. BAYARD GREEN, Biology Dept., Marshall College, Huntington 1, West Virginia.

*Editors*—Editor-in-Chief, PHILIP W. SMITH, State Natural History Survey Division, Urbana, Illinois; Book Review Editor, ERNEST E. WILLIAMS, Biological Laboratory, Harvard University, Cambridge, Massachusetts; and Index Editor, DAVID L. JAMESON, Dept. of Biology, San Diego State College, San Diego, California.

*Editorial Board*—Ichthyology: REEVE M. BAILEY, JAMES E. BÖHLKE, ROBERT W. HARRINGTON, JR., CLARK HUBBS, GILES W. MEAD, ROBERT R. MILLER, EDWARD M. NELSON, EDWARD C. RANEY, LIONEL A. WALFORD, LOREN P. WOODS. Herpetology: CHARLES M. BOGERT, EDWIN H. COLBERT, HENRY S. FITCH, WADE FOX, JR., HOWARD K. GLOYD, LAURENCE M. KLAUBER, JAMES A. OLIVER, CLIFFORD H. POPE, WILLIAM H. STICKEL, JOSEPH A. THEN.

## Officers of Western Division

*President*—EARL S. HERALD, California Academy of Sciences, San Francisco, California.
*Vice-President*—JAMES KEZER, University of Oregon, Eugene, Oregon.
*Secretary-Treasurer*—LILLIAN DEMPSTER, California Academy of Sciences, San Francisco, California.

## Officers of Southeastern Division

*President*—JOSEPH R. BAILEY, Dept. of Zoology, Duke University, Durham, North Carolina.
*Vice-President*—ELMER E. BROWN, Dept. of Biology, Davidson College, Davidson, North Carolina.
*Secretary-Treasurer*—WILLIAM J. RIEMER, Florida State Museum and University of Florida, Gainesville, Florida.

## Honorary Foreign Members

J. C. BATTERSBY; L. F. DE BEAUFORT; L. D. BRONGERSMA; FERNANDO DE BUEN; J. GUIBÉ; WALTER HELLMICH; CURT KOSSWIG; C. C. LIU; NICÉFORO MARIA; N. B. MARSHALL; KIYOMATSU MATSUBARA; ROBERT MERTENS; H. W. PARKER; H. RENDAHL; GUISEPPE SCORTECCI; J. L. B. SMITH; A. N. SVETOVIDOV; ETHELWYNN TREWAVAS; DAVID M. S. WATSON; G. F. DE WITTE.

## Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

---

Back numbers of COPEIA, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College, Huntington, West Virginia. Prices will be furnished on application.
Subscription, $9.00 per annum, $2.50 a copy.
Dues to Society: foreign and student members $6.00 annually; regular members $8.00 annually; sustaining members $25.00 annually.
Life membership: $150.00 single payment (may be purchased in annual installments of $25.00 each).
Patrons: $1000.00 single payment.
All memberships include subscription to COPEIA.
Dues and subscriptions are payable to the Society, through the Secretary.
Members should notify the Secretary immediately of any changes in address.
Manuscripts, news items, and all correspondence regarding the Journal should be addressed to the Editor.
Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced, carefully corrected. Galley proof will be furnished authors.
Original contributions from members of the Society, not to be published elsewhere, are alone acceptable.
Reprints are furnished at approximate cost.
Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author at the discretion of the Editor.

ΙΧΘΤΣ
ΒΑΤΡΑΧΟΣ
ΕΡΠΕΤΟΝ